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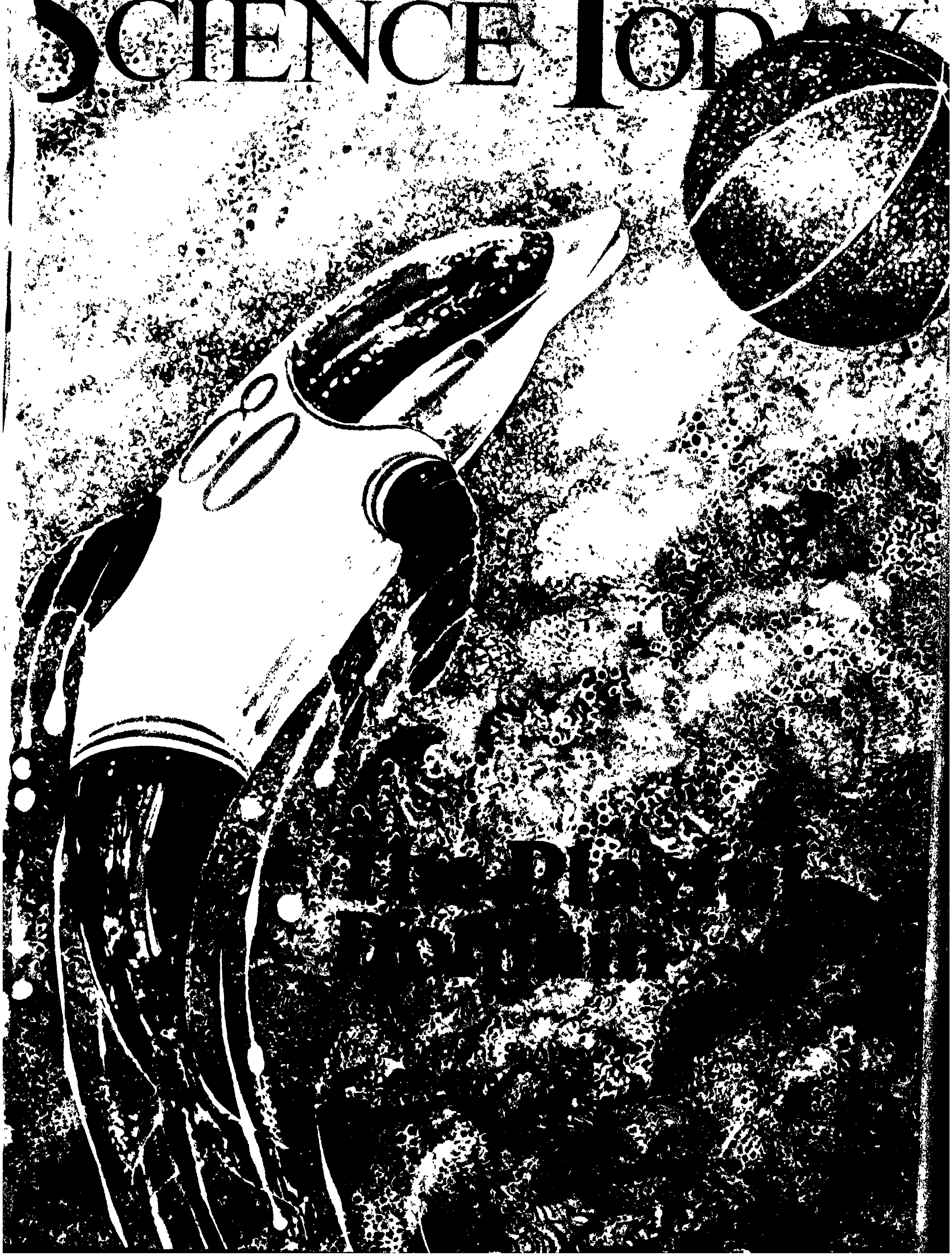
JANUARY 19[illegible] No 2

SCIENCE TODAY



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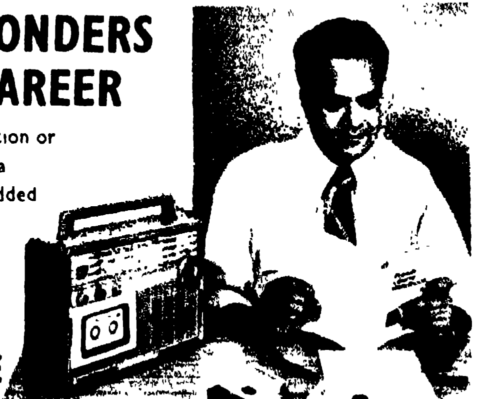

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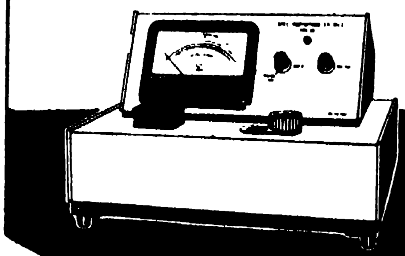

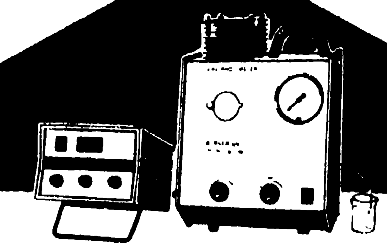

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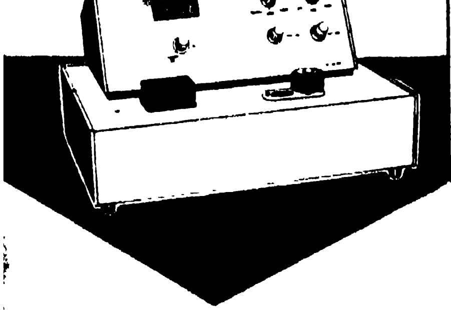

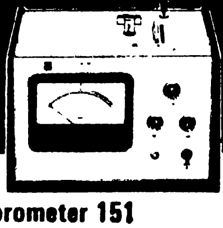

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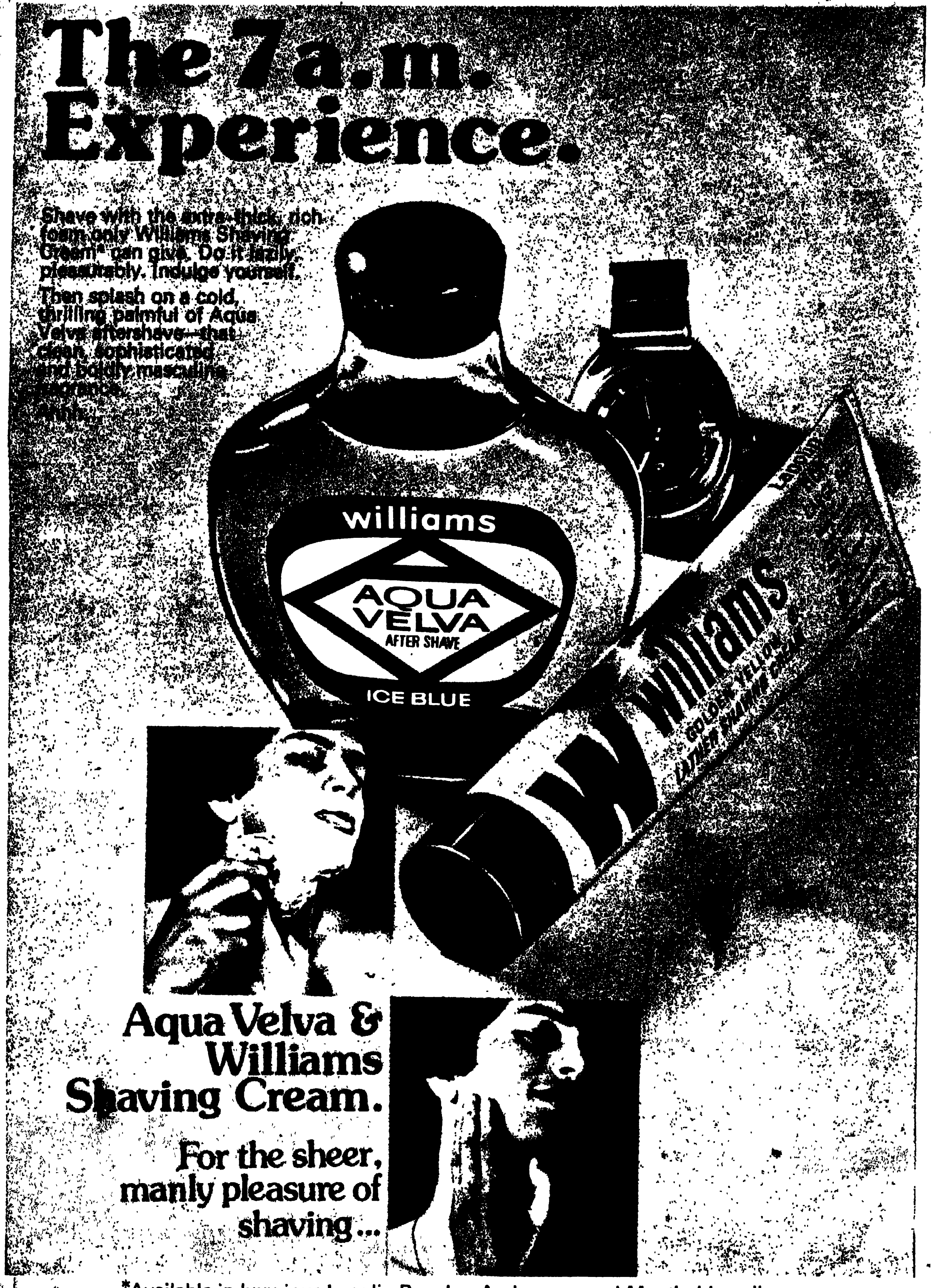

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Science Today

January 1980 Vol 14 No 1

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19 Basic forces of nature and their unification
Virendra Singh

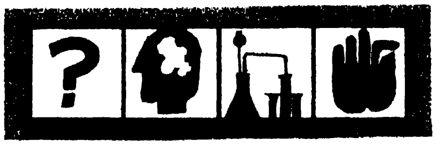
The first of a two-part review provides the backgrounder to the 1979 Nobel prizes for physics

28 Alcohol from cassava
C. Balagopalan
N. Hrishi

The hardy tapioca has the potential of being an important source of power alcohol

32 The playful dolphin
B F. Chhapgar

Attempts are now being made to communicate with this intelligent marine animal



47 The method of science

Beginning a series based on an exhibition that was quietly dismantled and disposed of one night in 1978 at New Delhi

49 A people's science movement in Kerala
V.K. Damodaran

The story of how science is being used to build up a mass movement for social revolution

59 How comfortable is your chair?
Krish Pennathur

63 The doctor as detective
Pritam P. Phatnani

In every case of suspicious death, it is the forensic expert who is called upon to provide the most vital clues

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☆☆☆

7 Letters
8 Viewpoints
12 View from New Delhi
13 Blurs & Bright Spots
15 Science Shapes Life
25 Round-up of Research
39 Books
40 Fun with Mathematics
42 Ideas & Inventions
43 Brain Teasers
45 If ..
55 The Bombay Mathematical Olympiad 1979
57 This World of Science!
57 In Lighter Moments
67 Tell Us .
69 You Too Can Do It

8 A cement policy for the 'eighties'
12 A slick solar power deal
40 The coloured cubes problem
42 De-ashing of coal
45 If there was no gravity
55 Maths olympiad

Cover design: Nana Shivalkar

Editor
Surendr Jha

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Single copy: Rs. 2
Subscription 1 year: Rs. 20,
2 years: Rs 39; 3 years Rs. 58.

Subscription queries and payments should be addressed to the Circulation Manager, Science Today, Times of India Building, Dr. D.N. Road, Bombay 400 001.

Printed and published for the proprietors, Bennett, Coleman & Co , Ltd , by T.P Pithavala at Usha Offset Printers Pvt. Ltd , 125, Govt. Industrial Estate, Kandivli, Bombay 400 067 General Manager. Dr Ram S Tarneja Branches. 7, Bahadurshah Zafar Marg, New Delhi 110 002, 139, Ashram Road, Ahmedabad 380 009, 105/7A, S N. Banerjee Road, Calcutta 700 014 Offices at. 13/1, Government Place East, Calcutta 700 069; 63, Montieth Road, Egmore, Madras 600 008, 407-1, Tirath Bhavan, Quarter-gate, Pune 411 002; 26, Station Approach, Sudbury, Wembley, Middlesex, London, U.K. London Tel. 01-903-9696

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THE MEANING OF SCIENCE

Mr Roy infers (A Search for the Meaning of Science, October 1979) that lack of available information and faith in divine power are the major factors that stand in the way of villagers becoming scientific. Mr. Roy has missed a lot. He starts wrongly, as his example of sanitary facilities indicates, and blames villagers for anything that is unsuccessful. My experience has been that villagers are responsive to activities that bring them immediate benefit.

S.L. Singwal
Fellow, Science Foundation Centre
Rajasthan University
Jaipur

I feel any analysis of the "meaning of science" should concern itself with the learning of laws, theories, structure, functions, etc, the fervour and capacity to discover them, and the technique—experimental, logical, speculative, etc—of analysing nature. A.K. Roy's article disappointed me. It merely contains an account of rural services conducted by a group of college students and the successes and failures of their ventures.

Ranjit V.R.
3/37 Ranga Colony
Madras 600 073

A.K. Roy has conveyed his message very well: that science is not for science's sake, it is for the people and by the people.

While the author's solution for the water problem in Uttar Pradesh seems appropriate, it is necessary for the experts to carry it out as quickly as possible.

Mahendra M. Shakya
Civil Engineer
Kathmandu, Nepal

While not questioning the sincerity of A.K. Roy, I would venture to suggest that he has missed the proper perspective, possibly because of his emotional involvement in his projects. Anybody will agree that science cannot by itself solve human problems without the help of other disciplines like economics and sociology. It appears as though Roy has struggled to unlearn a non-existent theory that science, by itself, can solve human problems and miseries.

L. Venkataraman
Scientific Officer
Atomic Fuels Division, BARC
Bombay 400 085

FLY ASH UTILISATION

At Koradi, near Nagpur, where the Maharashtra State Electricity Board is setting up a thermal power plant, huge quantities of fly ash are belched out every day through a water carriage system which costs Rs. 60 lakhs every year. The system is subject to repeated clogging, and has often to be supplemented by hiring trucks. In spite of this, the finer particles find their way into the Konkan river. The filtration plant downstream gets choked with the dust, making the water turbid.

A lot of research has been done on mass utilisation of fly ash, but the authorities have shown complete apathy. Every new thermal plant, I feel, must be integrated with a fly ash utilisation programme.

Finally, while M.K. Trivedi (Ideas & Inventions, October 1979) has done well in focussing public attention on the enormous wastage, his statement that fly ash contains 30 per cent of unburnt carbon seems to me doubtful. In fly ash analyses reports from three major power stations in Maharashtra — Koradi, Paras and Nasik — nowhere is it shown to exceed five per cent.

Vinoo Kaley
Principal Investigator for Construction Materials
Centre of Science for Villages
Wardha 442 001

G6PD IN THE HIMALAYAS

My finding on G6PD deficiency (Tell Us Why, October 1979) at high altitudes in the Himalayas is that the gene is well penetrated in the populations there. Since malaria has no access to high-altitude areas (above 3,000 m), the existence of G6PD deficiency there cannot be explained by the association hypothesis.

Also, unlike the sickle-cell gene, there is no definite clue about the possible advantageous character of the G6PD gene. The low frequency of this gene among the older people may, instead, indicate deleterious consequences for those who possess it.

With its low rate of mutation, what is required is a much wider observation, ecologically, genetically and culturally, before anything can be said about the resistance provided by the G6PD deficiency gene against a particular set of diseases.

Naresh K. Vaid
Dept of Anthropology
Delhi University
New Delhi 110 007

WEEDS: VILLAINS BUT GENIUSES

Nature knows no plants as weeds (Weeds. Villains or Heroes? October 1979) but the sum total of the effects will project a majority of the weeds as villains and not heroes. However, ecologically, weeds are genuises among plants.

P.S. Dubey
Reader & UGC Nat. Associate
School of Studies in Botany
Vikram University
Ujjain 456 010

"The water Hyacinth Has Its Uses", October 1979, interested me because I use the weed in a gobar gas plant. I have found that when about 6 kg of raw water hyacinth, well pounded, made into a paste and mixed with five times the amount of cow dung, is loaded into the gobar gas plant digester, it increases the methane gas output by 25 per pent.

I am also advised by the Khadi and Village Industries Commission of Kerala that the effluent from a gobar gas plant is one-and-a-half times more manurial if the hyacinth is added.

G.S.V. Krishnan
Kalpaka Nursery
West Nada
Guruvayoor 680 101.

PEOPLE'S SCIENCE MOVEMENT

A Consultation meeting of scientists, technologists and other professionals held recently at Somnath resolved to organise a "People's Science Movement" in Maharashtra. A resource and facility centre at Somnath will provide information, educational material and appropriate technology. It will also have a science museum. The centre will be known as "Jana-Vidgyan Kendra". As a first practical step, it has been decided to organise a *Vidgyan Yatra* in a few rural areas and in Bombay in the next six months. Persons interested in the Movement and in participating in the *yatra* may contact the undersigned.

Prerana Rane
Jana-Vidgyan Kendra
Somnath 441 224
(Dist. Chandrapur)
Maharashtra

AN ERROR

In my article "The Origin of Meteorites" (November 1979) there is an error in the labelling of Figs. 3 and 7. Fig. 3 is not that of the Patwar meteorite, but of the Richardton meteorite. The Patwar meteorite is shown in Fig. 7. The captions have been interchanged.

P.S. Goel
Prof. of Chemistry
IIT, Kanpur

A cement policy for the 'eighties

A CEMENT shortage seems to be a perennial phenomenon in India. Even though the installed capacity of cement has grown from about three million tonnes in 1948 to 23 million tonnes in 1978-79, demand has almost always exceeded supply. The present production of cement (which includes all types of Portland-based cements) is about 19 million tonnes per year which falls short of demand by about two million tonnes. Efforts are being made to narrow the gap by importing cement (for the first time in 25 years) and by offering incentives, like a rebate on excise duty for increased production, to existing factories. The government has also bold plans for increasing the cement capacity to about 35 million tonnes by 1983 and to 53 million tonnes by 1988.

How far are these ambitious plans feasible? If the installed capacity is to increase from 23 million tonnes in 1978-79 to 35 million tonnes in 1983, funding becomes a major consideration. Taking an investment of Rs.650 per annual tonne capacity as standard for new cement factories today, the industry would need a total investment of Rs.850 crores up to 1983. Though the availability of funds relates to the profitability of the industry and the overall economy of the country, it can still be managed through suitable priorities and pricing.

But let us first examine the problems faced by the industry. Many of these are technical; the others are organisational. A rational cement policy would have to consider:

- studying the present factories to maximise production by rehabilitation and modernisation
- converting some of the existing wet-process rotary kilns to either dry-process or semidry-process kilns
- converting some of the existing dry-process suspension preheater kilns to the modern precalcination process
- making available raw materials, especially limestone and coal, for new factories
- the timely availability of plant and machinery for new factories
- identifying the optimum process of manufacture and importance of split location
- evolving a strategy for mini cement plants, and
- making available cheaper cement for rural housing.

Of the 53 cement factories in India, 30 are more than 20 years old and are, to some extent, obsolete. But, owing to the economic conditions prevailing in the country they have not been, and cannot be, scrapped. And they need not be The efficiency of some of these factories can be raised by rehabilitation of worn-out plant and machinery and proper preventive and routine maintenance can increase their production substantially. Consider the typical case of a factory with machinery, on an average, 20 years old and a rated capacity of 8.6 lakh tonnes per year, but producing only 7 lakh tonnes. It can be revamped at a cost of about Rs.10 crores to produce 9.5 lakh tonnes (including Portland pozzolana cement) per year. In other words, the investment per annual tonne of increased production is only Rs.400, compared to more than Rs.650 per tonne for a new factory of equivalent capacity.

In fact, of the 50 such factories which the Directorate General of Technical Development (DGTD) got examined during 1976-77, to identify ways and means of raising production and efficiency, some have already carried out improvements. This sort of exercise, if carried out every five years or so, may prove to be very fruitful. Indeed, some factories may require no more than just one or two vertical shaft kilns of capacities 100 or 150 tonnes per day, with a minimum addition of other machinery, to achieve a higher output at a very low investment and production cost.

Again, the National Building Code brought out by the Indian Standards Institution has advised that Portland pozzolana cement (a blend of finely ground burnt clay or fly ash with cement) and Portland blast furnace slag (PBFS) cement (a blend of finely ground blast furnace slag with cement) should be taken as equivalent in every respect to Portland cement for all ordinary constructions. Therefore, all cement factories, except those already making PBFS cement, could convert half of the clinker produced to Portland pozzolana cement. This would increase production by about 10 per cent at very low costs. It is imperative, however, that they make their own pozzolana by burning either raw clay bricks or shales available at site. They must not rely upon broken brickbats, supplies of which are uncertain.

Similarly, some of the cement factories which are situated near thermal power stations should think of utilising the available fly ash to make Portland pozzolana cement. Of course, the power stations must arrange to supply dry fly ash in bulk, or packed in bags. They should also assure a regular supply of uniform quality.

Low production is also partly due to the railway's incapacity to transport limestone. Fortunately, 80 per cent of the cement factories are located within 40 km of limestone deposits. But the remaining, which get their supply of limestone by rail, often suffer because of the delay in railway transport. Coal receipts are also similarly curtailed. For instance, during the period January to March 1979, while the cement industry required an average of 538,000 tonnes of coal a month, the coal despatched to them was only 408,000 tonnes a month. This led to the situation where 31 factories, representing 57 per cent of the cement manufacturing capacity, faced a critical coal supply position.

Again, cement is preferably despatched in covered watertight wagons. But there is always a shortage of such wagons, specially during the harvest season. Problems also arise when the collieries cannot supply coal of the required quality. Power cuts are another constraint.

It is necessary to modernise the process of cement manufacture, and the modern practice is to use the dry process. But of the 53 cement plants in the country, 36 have wet-process rotary kilns, and except for three comparatively new ones, all are more than 20 years old. Of the three relatively new kilns, one has already been successfully converted to the dry process and another may be converted soon.

The older kilns can be converted to the dry process in a number of ways. One way is to convert them to a straight dry-process kiln which will yield an extra output of about 20 per cent and will also lead to a 20 per cent saving in coal, due to the relative increase in efficiency. The other would be to cut the kilns to about three-fourth their length and fit them with suspension preheater cyclones; this would increase production by about 40 per cent, with a commensurate saving in coal. A third way is to convert them to the semidry process by installing vacuum slurry filters and a small dry raw mill, and mixing the filter cake and dry meal to form nodules which are then fed to the rotary kiln. This alternative can also give 20 per cent higher production and save on coal consumption.

Of these three alternatives, the first is the easiest, because the existing raw mill can be converted into a cement mill and a new dry raw mill installed. The second alternative is a little more complicated; it will be necessary to install a dry raw mill, cut the kiln, and install suspension preheater cyclones. The two wet-process kilns which have so far been converted to the dry process have been altered in this manner. The third alternative is still at the experimental stage. But the economics and the relative efficiencies of the three alternatives have yet to be fully studied.

During the last 10 years, a new innovation in dry-process suspension preheater rotary kilns has been the firing of coal or oil in a chamber called the 'precalciner'. It can increase the production of the rotary kiln by about 50 per cent without any increase in the size of the kiln. A cement machinery manufacturer in India is also collaborating with a Japanese firm for installing precalciners on some existing dry-process kilns and is making new kilns with suspension preheaters and preclaciners. If the first few kilns with precalciners run satisfactorily in India, it is reasonable to expect that most of our dry-process kilns will eventually be equipped with precalciners.

Raw materials and machinery

India has 'indicated' and 'inferred' reserves of about 40,000 million tonnes of limestone and about 75,000 million tonnes of non-coking coals. Limestone is found everywhere in India except in West Bengal and Punjab, though coal occurs only in the eastern and central regions. Even with these limitations, limestone and coal reserves are sufficient to sustain very high levels of cement production. It takes 200 to 250 kg of coal and 1.3 to 1.5 tonnes of limestone to make a tonne of cement by modern processes. Obviously, transporting coal to cement manufacturing sites should not pose a major problem, but cement factories will necessarily have to be situated close to limestone quarries. However, some of the largest limestone deposits occur in areas where the rail network is either poorly developed or nonexistent. This is especially so in Rewa and Bastar districts of Madhya Pradesh and in parts of Rajasthan. Additional railway lines to these areas will need to be laid if the limestone deposits are to be suitably exploited.

Availability of cement manufacturing machinery is another factor. In the last 20 years, only indigenously manufactured machinery has been used for setting up new cement factories in India with only a very small proportion of the equipment being imported. Given our ambitious targets, will the indigenous manufacturers be able to meet the anticipated demand? A few years ago, the production capacity of the six major cement machinery manufacturers was about 12 cement plants per year of 600 tonnes per day (TPD) capacity. This gives a possible increase in the capacity of cement production by about 2.4 million tonnes per year. But if all the present cement machinery manufacturers gear themselves to producing 1,000 to 1,200 TPD plants and they can manufacture machinery for at least eight cement plants per year, there can be a possible increase in capacity of about 3.2 million tonnes per year. As mentioned earlier, the government has planned for an increase in cement capacity from 23 million tonnes in 1978-79 to 35 million tonnes per year by 1983, an increase of about 3.25 million tonnes per year. Cement machinery manufacturers should be able to meet this target, provided that

Trends in cement-making technology

CEMENT, or more correctly, Portland cement, is a fine chemical made from some of the most abundant materials on the earth's crust. It is manufactured by grinding together calcareous substances such as limestone and chalk with argillaceous materials such as clays and sandstone and burning the mixture until a residue called 'clinker' is formed. This clinker is again ground and mixed with a small quantity of gypsum (calcium sulphate) to get the final product, Portland cement.

The composition of the raw materials and of the cement has to be kept within narrow limits, the material burnt at a precise temperature and the burnt material ground to a predetermined fineness. For instance, cement should have a chemical composition of about 60 to 66 per cent lime (CaO), 19 to 25 per cent silica (SiO_2), between two and eight per cent alumina (Al_2O_3) and 0.3 to six per cent iron oxide (Fe_2O_3).

Thus the manufacture of Portland cement entails crushing, grinding, blending, burning and regrinding, all of which are chemical engineering unit operations. Grinding is the most important, and of the total of about 120 kWh of power required to produce one tonne of cement, about 80 per cent goes for grinding only—grinding of the raw materials, coal and finished cement. The coal consumed in burning may vary in weight from 18 per cent to 33 per cent of the cement made. Thus the overall efficiency of a cement plant is largely determined by its grinding and burning efficiencies.

The raw materials, especially limestone, are first crushed from the run of mine size to less than 25 mm. The power required may vary from three to five kWh per tonne of limestone crushed. After crushing, the limestone and other additives (clays, iron ore, etc) are ground to a very fine mesh (70 openings per linear cm) to facilitate the fusion and reaction of the individual compounds in the kiln.

Depending on the raw material characteristics and the burning process used, the grinding may be done in a dry or a wet state. In the wet process, crushed limestone and clay are ground together with around 30 to 40 per cent water and the resulting slurry is fed to the kiln. In the dry process, the raw mix is ground in the dry state.

For burning the raw mix, three distinct processes are available: (i) the wet process, in which the raw mix is ground with the addition of 30 to 40 per cent water and the slurry fed to the burning equipment (kiln); (ii) the dry process, in which the raw mix is ground dry and the dry raw meal fed to the kiln; and (iii) the semidry process in which the raw mix is ground dry and the ground raw mix is then made into pellets by adding 10 to 12 per cent water and the pellets or nodules fed to the kiln. For burning the raw mix, coal, furnace oil or natural gas can be used. As natural gas is scarce in India it is not used in the cement industry. Furnace oil, being very costly, is used only for making white cement or as a booster in some of the coal-fired kilns. Thus, coal is the only fuel available to the Indian cement industry. There are many modifications of these three basic burning processes and the relative efficiencies of some of these are given in the Table. Though vertical shaft kilns are sometimes used, rotary kilns are the preferred burning equipment because of their higher productivity.

An important recent development in cement technology is the introduction of a precalciner. An ordinary rotary kiln has three zones: preheating, calcining and sintering. (Calcining refers to the heating of the raw mix under oxidising conditions so that the carbonates in the raw material are turned into oxides by the liberation of carbon dioxide, while sintering refers to the fusion of the calcined material to form nodules called clinker.) In the 'fifties, an important innovation had been the introduction of the dry-process suspension preheater (SP) all the necessary inputs are available to them in time.

Suggestions have been made that cement machinery manufacturers should join together and standardise their equipment. This is not a very logical step, since each manufacturer has collaborated with different foreign firms, whose differing designs would make standardisation impossible. On the other hand, distinctive designs of machinery should create a healthy sense of competition.

Supply of internal and external material-handling and transport machinery is very important for the cement industry, especially for large-capacity factories. In this context, the growth of quite a few transport machinery manufacturers in India, who can increase their capacity as the demand rises, is an encouraging sign.

Split location

The dry process, with suspension preheater kilns, has proved its superiority in thermal efficiency and reduction of down-time over every other known process for the manufacture of Portland cement clinker. Plants of capacity up to 3,000 TPD are in operation today. Even in India, dry process with suspension preheaters is to be preferred, unless the available raw materials are not suited to such kilns, or they cannot be ground dry. The use of precalciners is also worth considering, specially since they will result in smaller rotary kilns. The difficulty in transporting large machinery by rail or by road may make it necessary to design machinery to overcome these constraints. Similarly, the sizes of the balancing equipment, such as crushers and the grinding mills, need to be optimised to suit the rotary kiln capacity.

In view of the difficulties felt by the railways in supplying covered wagons for the transport of cement, the concept of split location is becoming increasingly important. (Split location refers to the planning of manufacturing facilities in such a manner that the clinker manufacturing kilns are located near limestone deposits, while the clinker is ground near cement-consuming areas.) The advantage here is that the clinker, unlike cement, can be transported in open wagons. It has also been estimated that transporting clinker in open wagons to the consuming centres that are over 400 km away (where the grinding units have to be situated) will be cheaper than the transport of bagged cement in covered wagons. Since the average distance to which cement is moved is 676 km (1977-78 figure), the saving would be considerable. The concept of bulk handling and transport of cement also needs to be examined.

Mini cement plants

Large-capacity cement plants can be located only where proven deposits of the required grade of limestone are enough to meet production needs (including possible future expansions) for 50 years. Smaller deposits are scattered all over the country; though these cannot support a large-capacity cement plant, they will be sufficient for plants with capacities of 60,000 tonnes per year or less. Besides making cement available in remote underdeveloped districts at lower costs, the installation of a small capacity cement plant in such areas would increase employment opportunities. A mini cement plant would, therefore, be ideal for such locations. The Cement Research Institute (CRI) has identified some 200 such locations in the country. The government has announced that a plant with capacity less than 200 TPD (or 66,000 TPY) will be considered as a mini cement plant, and has sanctioned a 50 per cent rebate on excise duty for such plants for a period of five years.

kilns. In this process, hot exhaust gases from the rotary kiln are used to preheat and partially calcine (30 to 40 per cent) the ground raw material in a series of heat exchangers called cyclones. However, as suspension preheater kilns increased in size to capacities of 3,000 to 4,000 tonnes clinker a day, problems arose in their manufacture and transport; there was also a greater refractory wear due to increasing thermal loads in these kilns.

To overcome these difficulties, the technology of precalcination was developed by around 1970. In this system, some fuel (pulverised coal or furnace oil or natural gas) is fired at or near the lowest cyclone at the inlet end of the rotary kiln, so that the raw mix is practically completely decarbonated before it enters the kiln and thus reduces the thermal load in the rotary kiln. Thus the same kiln which produces, say, 2,000 tonnes of clinker per day may give an output of even 3,000 tonnes on introduction of the precalcination system.

Five or six different modifications are in use now, either of the fluidised bed type or of the flash furnace type. In a fluidised bed calciner system, the cement raw meal from the third stage of the suspension preheater cyclone is introduced into the fluid bed. About 20 per cent of the pulverised fuel is burnt in the fluid bed and the raw meal is retained in the fluid bed from three to eight minutes. About 88 to 95 per cent of the raw meal is calcined in the fluid bed itself. One advantage of this system is that it can be brought into operation or cut off according to the level of output desired, without any loss in thermal efficiency.

Precalciners using the flash furnace burn around 55 per cent of the fuel in the flash furnace and the retention time of the raw meal is around two to three seconds. The accompanying diagram shows the process flow sheet of a suspension preheater system with a flash furnace.

Most of the dry-process kilns to be installed in future are likely to have precalcination systems. Even on existing dry-process kilns, it is possible to install precalcination systems. Similarly, some existing SP kilns can be modified to accommodate precalciners with a 40 to 50 per cent increase in capacity. A few SP kilns of capacity 600 TPD are already in the process of being modified to accommodate precalciners. Their expected output is between 800 and 900 tonnes of clinker per day. The first of such kilns is likely to be commissioned in early 1980.

Relative efficiencies of cement manufacturing processes

	Kcal/kg clinker		Per cent coal used	
	Average	Best achieved	Average	Best achieved
Long wet-process kiln	1450	1300	29	26
Long dry-process kiln	1350	1100	27	22
Short semidry-process kiln with travelling grate heat exchanger	950	700	19	14
Short dry-process kiln with suspension preheater cyclones	900	700	19	14
Short dry-process kiln with suspension preheater cyclones and 'precalcination'	900	700	19	14
Vertical shaft kiln	1200	1000	24	20

Besides this, the cement produced will be exempt from the freight pool but will be under the cement control order as far as the price of cement to the consumer is concerned. Moreover, plants situated in remote hilly areas may enjoy a higher rebate on excise duty.

With all the fiscal advantages, a mini cement plant with capacities ranging from 50 TPD to 200 TPD should be viable. Mini cement plants are not new to India. In fact, the first few cement plants established in India would be considered mini plants today. All the old plants were rotary kiln-based, two of which were dry. Thus, we have the knowledge for the design and operation of rotary-kiln-based mini cement plants, both wet as well as dry. Though the first cement factory installed in India had a vertical shaft kiln, these were discarded by 1920 and we have thus lost this technology. The Regional Research Laboratory (RRL), Jorhat, has carried out considerable research on vertical shaft kilns of capacities less than 50 TPD and they now also have the design data for larger capacity vertical shaft kilns. These designs can be utilised for setting up mini cement plants.

Though over 40 letters of intent or licences for mini cement plants have been issued by the DGTD so far, only 15 plants are being built. This is probably due to either uncertainty of profitability, or want of economical means of getting the detailed project report made, or not finding reliable parties for supplying the main plant and machinery at an economical price.

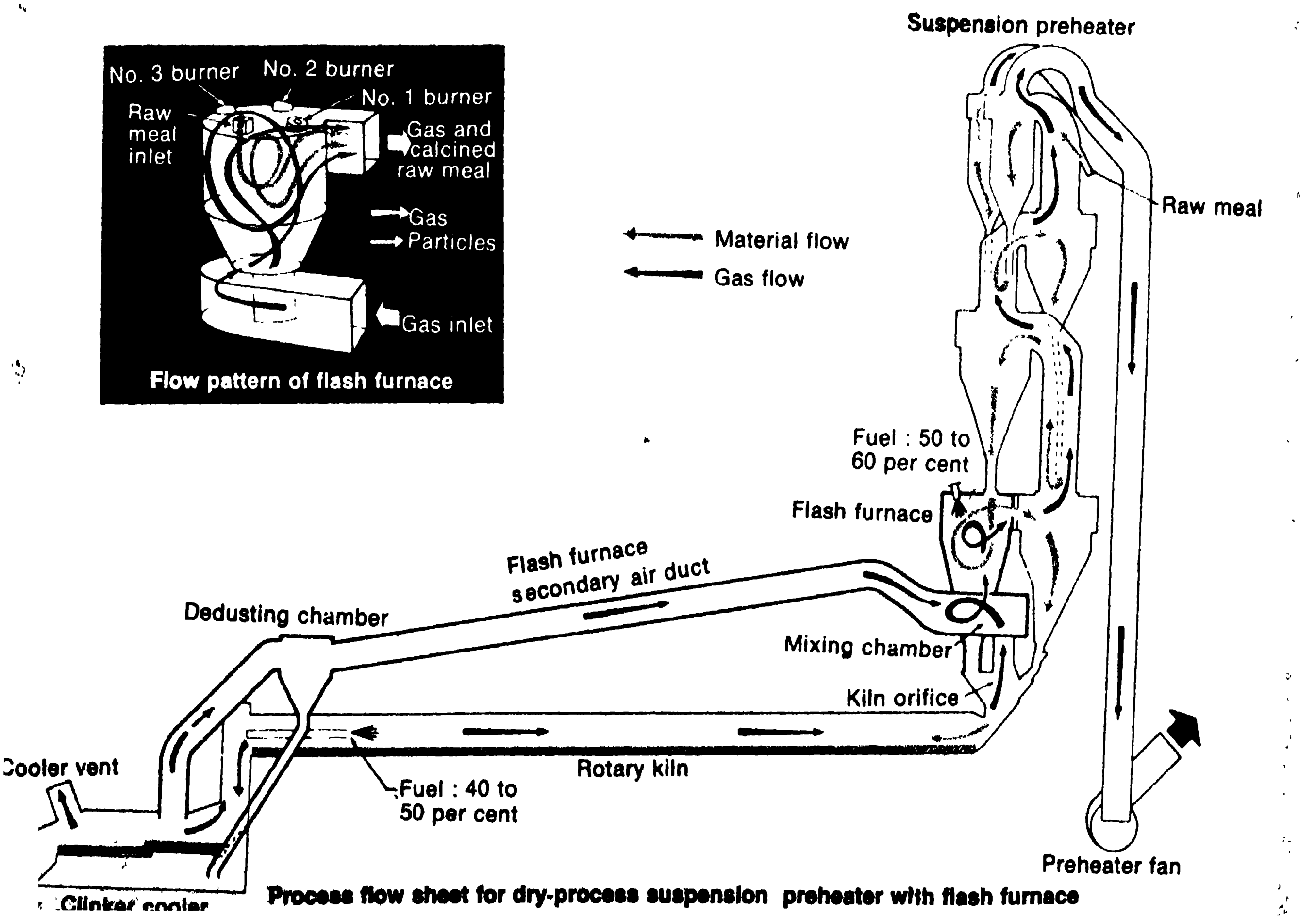
Any cement policy must take into account the conditions prevailing in rural India. A lot of interest has been shown recently in developing cheap cementitious materials to replace Portland cement. In India, lime-surkhi was the most common building material for centuries, until its use became less popular with the advent of Portland types of cement. It should be our aim to develop cementitious materials which could be made in remote villages without the help of any advanced technology. Many such cementitious materials have been developed recently. The Central Building Research Institute, Roorkee, G.B. Agricultural University, Pantnagar, UP, and the Indian Institute of Technology, Kanpur, have developed processes for making rice husk cement. Similarly Khadi Gramodyog, Aurangabad, has developed a lime-surkhi type of hydraulic cement and named it 'Lympo'. Plastic clay mixed with bran or finely chopped straw can also be used as a binding material in comparatively dry locations.

To ensure that this technology is widely used, certain measures are, however, necessary. As a first step, the National Buildings Organisation (NBO) can: (a) list all types of cementitious materials; (b) list all the raw materials required for making them; (c) chalk out the exact method of making and using them; (d) identify locations where such cements could be made with raw materials available locally; and (e) advise people on the types of construction for which these cements can be safely used.

When the NBO has detailed all the necessary information, block development officers in each district should advise villagers in the manufacture and use of these cements. If such measures are followed, it would help ease the demand for Portland cement and release it for projects where its use is necessary.

H.N. BANERJEA

Mr. Banerjea is a chemical engineer who was with the Associated Cement Companies Ltd for about 20 years till he retired in 1971. He has done pioneering work in the field of cement manufacture in India and now works as an adviser to a firm of consultants.



Flow pattern of flash furnace

Process flow sheet for dry-process suspension preheater with flash furnace

Solar power deal under a shadow

TECHNOLOGY import has been the topic of scores of national and international conferences, and reports and recommendations made so far may fill a small library. Yet, they have made little impact on Indian planners. The recent move to import the technology for making solar-powered pumps indicates this.

According to a proposal backed by the Ministry of Rural Reconstruction, Indian Detonators Limited (IDL), a private firm in Hyderabad, will import 1,000 solar pumps, 100 in the first year and 900 in the second year, from Solar Electric International (SEI) The pumpset consists of three parts—silicon photovoltaic (PV) modules that convert sunlight into electricity, a water pump, and an electronic power optimiser that is interfaced between the PV modules and the pump. Each pump will cost Rs.50,000.

The ministry says that IDL will sell the pumpsets to farmers at Rs.11,000 apiece and write off the balance as "promotional" loss. In the third year, IDL and SEI will jointly set up a Rs. 18-million factory in Bhubaneswar, Orissa, employing about 500 professionals, for the manufacture of SEI solar pumpsets. The Orissa government will bear 20 per cent of the cost; the balance will he shared equally between IDL and SEI. The factory is estimated to make 10,000 pumpsets a year, and the cost of each pumpset is expected to come down to Rs.11,000 in five years.

The proposal also includes a barter deal under which metallurgical grade (85 per cent purity) silicon will be exported from India in exchange for semiconductor-grade silicon wafers for the PV modules.

But the controversial part of the proposal is the five-year customs-duty-and-octroi exemption claimed for the pumps and the manufacturing facilities required at the proposed factory. The Ministry of Rural Reconstruction has forwarded the proposal to the Prime Minister, with the Finance Minister's suggestion that it may be approved.

A few questions seem relevant. Why is the proposal being pushed through on the eve of the general elections? More important, is it necessary to import technology to make PV modules when the government-owned Central Electronics Limited (CEL) near Delhi can manufacture them? As for water pumps, at least three firms in the country are already making them, using imported technology, and are willing to go for high-efficiency pumps if they are assured a firm bulk order.

In other words, solar pumpsets can be made in large numbers with the existing knowhow provided the government is keen and is willing to invest money to expand the CEL's production base. In fact, CEL already has the PV technology which SEI will bring to India three years from now. The Ministry of Rural Reconstruction has, however, stated that the import of "a few" solar pumps will neither kill the indigenous solar technology nor open up the country for multinationals. And SEI, it is stated, is not a multinational but a three-man firm.

Who are these three men, who, with the help of IDL, have come up with a scheme to put up the biggest solar pump factory in India? They are: Dr. S.V. Allison, Mr. S.W. Allison, and Dr. R.W. Matlin. Dr. S.V. Allison worked for over 10 years in Orissa as a World Bank groundwater expert. He had fully studied the Orissa lift irrigation system and collected extensive agro-climatic data as part of a World Bank assignment. He then quit the World Bank to found SEI, and became its managing director. The SEI solar pumps were, no doubt, tailor-made for Orissa and the Gangetic plains. Mr. S.W. Allison is the managing director of a building firm in Nairobi of which Dr. S.V. Allison is a partner. Dr. Matlin, who had worked at the Lincoln Laboratory of the Massachusetts Institute of Technology, USA is the only man in SEI with experience in solar systems.

SEI bought the best PV modules and the best pumps available in the United States. It made six pumpsets by assembling off-the-shelf components and these were sold to IDL; two of these pumpsets were gifted to the Orissa government and two to the Union Ministry of Agriculture The rest two were shown around the country to government officials, including the Minister for Rural Reconstruction.

Though SEI is not a multinational, it buys the components for the pumpsets from multinationals. The PV modules of the SEI pumpsets are from Solerax, a firm collaborating with Montedison, an Italian multinational. The power optimiser (which, incidentally, contains several integrated circuits and hence is not a simple technology) is a standard model used in spacecraft and made by multinationals. In fact, SEI does not possess any technology of its own. Its role in transferring technology, therefore, becomes questionable.

There is another question to be considered. Is it right on the part of the World Bank to allow its experts to commercially exploit a developing country using data gathered by them when on an assignment to the country? It should be noted that SEI's interest in India is purely commercial. SEI is registered in the Isle-of-Man, a British island, where no industry is required to pay taxes.

What is surprising is that the Department of Science and Technology, which is funding CEL's PV project, has not raised any objection to IDL's import of technology from SEI, although the Electronics Commission is strongly opposed to the proposal. One should also note that IDL's chairman, Mr. M. Varadarajan, is a member of the Society of the Council of Scientific and Industrial Research (CSIR) which is under the Department of Science and Technology.

Solar-powered water pump is only one of the several potential applications of solar energy for which there will soon be a tremendous market in rural India. Naturally, multinationals are not going to sit idle and watch. Unless the Indian government is alert and launches a massive research programme to harness solar power, the Indian industry will lose the market to others.

K.S. JAYARAMAN

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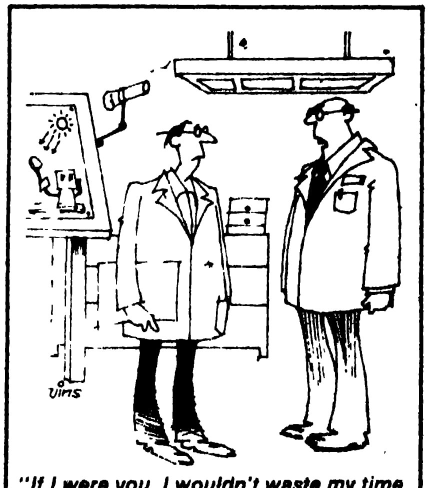

"If I were you, I wouldn't waste my time designing a petrol pump which works on solar energy."

The prize-winning style

THE ANNOUNCEMENT of the Nobel prizes each year invariably initiates a debate on the merit of the work of the awardees in comparison with that of the previous winners. Debate and speculation also centre around the environment in which the laureates worked and on their motivation and style of working. In India the award provides an occasion to lament the absence of an invigorating scientific environment and to dream wistfully of the prizes we could have won if the situation was different. Environment, motivation and style—is there any discernible pattern that sets Nobel prize winners apart from others?

Consider the biological sciences. The prize for medicine last year was awarded to a physicist (A. M. Cormack) and an engineer (G. N. Hounsfield) for developing computer-assisted tomography (see SCIENCE TODAY, December 1979, p. 60). The award once again demonstrated that a problem faced in one discipline often finds a solution in another. In this case, the problem was posed to Cormack by a colleague who was a radiologist. Although the mathematical principle underlying tomography was known for quite some time, Cormack set out with the singular objective of demonstrating its practical possibility. He did so by carrying out simple experiments with a model structure fabricated out of leucite and aluminium and using ^{60}Co and ^{60}Ni as gamma-ray sources—facilities that were available to Indian scientists during the early 'sixties.

The 'fifties and the early 'sixties were the most exciting period in modern biology. It was at this time that many individuals came into the limelight. Being a graduate student during the late 'fifties, I too was able to share some of the excitement of that period. I was also able to get some feel of the environment that then existed, the motivation that guided those scientific workers and their style of functioning. What follows is based on casual observation and general impressions gained during this period rather than on any systematic study of the lives and work of these pioneers.

Much has been said about the role of luck in scientific discovery. In India, as elsewhere, luck has always been a ready excuse for all our misfortunes. If we fail, we blame it on our bad luck; when others succeed it is because of their good luck. The discovery of penicillin by Alexander Fleming, for which he was awarded the Nobel prize in 1945, has been attributed to a chance contamination by the mould penicillium. Fleming himself said as much in his Nobel lecture. He remarked that it would be "untrue" to claim that the discovery came about from a "serious study of the literature and deep thought". But Peter Brian Medawar, himself a Nobel laureate, while analysing the role of luck in scientific discovery remarked that Fleming, having had firsthand experience with infected wounds during World War I, had always thought of discovering a drug to fight infection. It is this preparedness of his mind that made him not only *see* the halo around the mould but also take *notice* of it.

These days, the emergence of science as a highly organised activity supported by public funds has robbed it of the romanticism that is always associated with any creative endeavour of mankind. Excessive regimentation and a strong hierarchical order that are implicit in all forms of organised activities have also eroded the very basis of the creative expression in the individualism of the creator. James Watson, the author of *The Double Helix*—the book that has been both criticised and appreciated more than any other book in its category—has made no bones about his abhorrence for organised science. In the prologue to his Nobel lecture, he remarks, "Almost as soon as I set foot in Cavendish, I inwardly knew that I would never be of much help to John (Kendrew). Perhaps even without Francis (Crick) I would have quickly bored of myoglobin." Watson and Crick carried on working on the DNA structure despite the annoyance of their superiors, who (perhaps rightly) thought that because of this "side preoccupation" they were not doing justice to their professed programmes. Having unsuccessfully tried to change these non-conforming individuals the response of Sir Lawrence Bragg, at that time the director of Cavendish, was, "Let Jim and Francis have their fun."

In contrast, the work of Francis Sanger, who won the Nobel prize in 1958 for working out the structure of insulin, falls in a different class. The problems he faced were truly formidable, specially since the methodology he used was primitive by present-day standards. Supported by just a couple of technicians and one or two students, he doggedly pursued his objective in spite of the scepticism of his colleagues. The Nobel committee, which was aware of his ordeal, remarked, "Now that many years of work have been crowned by success you may look back and rejoice. However, you are more apt to look ahead." And that's what Sanger did. He moved into the area of nucleic acids, and developed a method for the separation and analysis of oligonucleotides that has now become an indispensable tool for studying the structure of nucleic acids.

The case of Marshall Nirenberg, who was awarded the prize in 1968 for his work on the genetic code, falls in a different category. His work was not characterised by either the romanticism associated with the work of Watson and Crick on DNA structure or the gruelling struggle, spanning over a period of 10 years, of Sanger. The time was ripe. The concept of messenger RNA was already firmly established by Francois Jacob and Jacques Monod. Severo Ochoa had discovered an enzyme called polynucleotide phosphorylase for which he won the Nobel prize in 1959. Given the building blocks, this enzyme could produce synthetic RNA of any desired composition. All that was needed was a fresh and uninitiated mind to go beyond the logical considerations and put this information together.

Nirenberg was just out of graduate school, and was an obscure scientist with the National Institutes of Health, USA. If Nirenberg had approached the problem in a conventional manner, he would have had to wait for several years for the isolation of natural messenger RNA from a cell. However, he used the synthetic messenger RNA produced by polynucleotide phosphorylase, and this eventually led to the cracking of the genetic code.

The point I want to make is that science has been, and still is, very much of an individual activity. Many of these individuals did their early work under circumstances where research facilities were minimal. The well-equipped laboratories and institutes came after they had made their mark in science. We in India, having been unable to cope with the present, have lost our ability to project into the future. The only logical course left to us is to either seek refuge in the past or to imitate the West. In fact, we follow both these courses. The dichotomy inherent in this does not bother us, as we have learned to live with such inconsistencies in all spheres of activity. The relevant question I wish to raise here is: we can imitate the set-up of these individuals as it exists today, but can we replicate the men behind it? Even in the art of imitation we are poor performers. We have been imitating the West in body, not in spirit.

U. N. SINGH

Dr. Singh is Reader in the Molecular Biology Group of the Tata Institute of Fundamental Research, Bombay.

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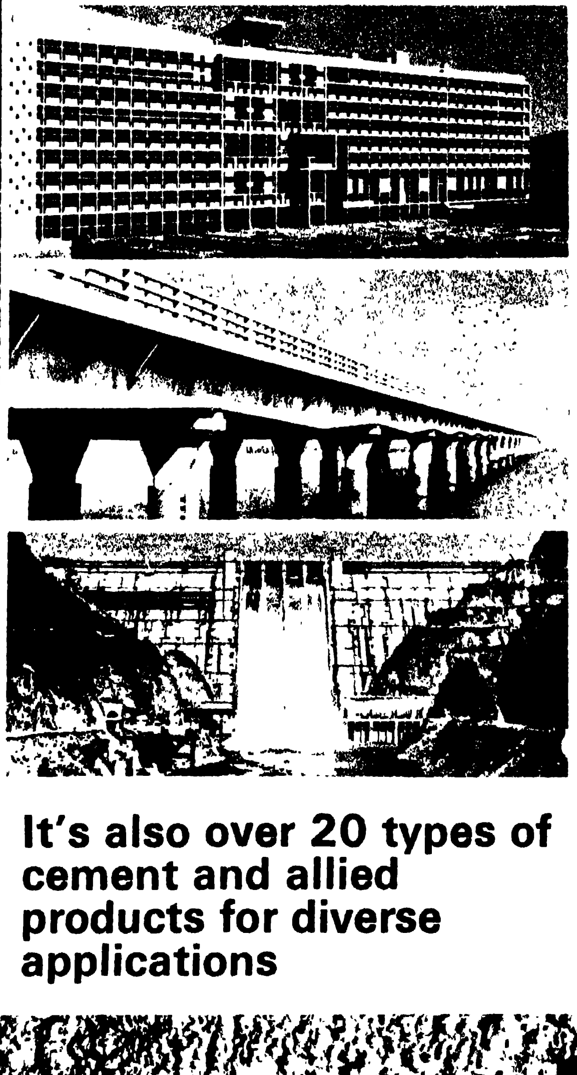

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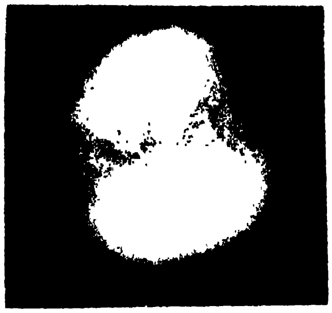
Science Shapes Life

CLOUDY NEPTUNE

The last but one planet of the solar system is some 30 AU (Angstrom units) from earth (the sun is one AU away). Being only about four times as large as the earth in diameter, to observe it in detail telescopically is difficult. Too faint for the naked eye, telescopically it appears as a small greenish disc.



But recently University of Arizona scientists have managed to get a clear picture of this planet. The photographs were taken through the university's 1.54 m Catalina telescope. These pictures suggest that it has a cloudy atmosphere. And there are absorption bands of 7,260, 8,900 and 10,000 Angstroms, meaning that methane is one of the constituents of the cloud.

The "discrete cloud features", in fact, show a pronounced central dark band bounded by bright regions on either side. These bright features are probably high altitude clouds of methane ice, says team leader H.J. Reitsema. Below this there may be a gaseous layer of methane.

The planet was observed for one hour and 40 minutes during which its surface features appeared to be moving in the direction of rotation of the planet. The bright region in the northern hemisphere appeared to be quite narrow, unlike a fairly large portion of the hemisphere south of latitude 30°S which was luminous.

SOCIAL SPACE

Have you noticed how in a sparsely filled bus, train compartment or library, strangers tend to sit far apart? Of course, in a crowd this distance is done away with. According to D. J. Oborne and T. O. Heath, Department of Psychology, University College, Swansea these considerations of social space are important to ergonomic studies.

The distance maintained between two people depends on their intimacy. When you are close to a particular [illegible] don't mind being 'close with' him either. Thus the distance separating two acquaintances walking on a street is usually less than that between two strangers.

Personal space is an area with invisible boundaries around a person's body into which intruders may not enter. The area decreases with increase in levels of intimacy. Studies have indicated that infringements cause arousals. There are certain other rules too in space maintenance, for example, the gaps among people of different cultures. Also, women have smaller zones of personal space. When dealing with persons of their own age group, people tend to come nearer than when they deal with older persons.

Like social space adjustments, people also mark a territorial zone, often with visible boundaries. In the animal world the marking is done by scent.

Ergonomic designs to increase efficiency can be enhanced by taking these space factors into consideration. One example is that of a well-designed seat. If such seats were placed close to one another, their value might decrease since personal space requirements of the two people could be infringed.

RABBITS FOR FOOD

Remember how rabbits overran Australia? Of course it was a case of predator-prey imbalance. But then the rabbits are also extremely prolific. Ghana now has plans to make use of this fact and farm rabbits to meet its demand for animal protein. In rice and maize, Ghana is almost self-sufficient.

The National Rabbit Project of Ghana, which put in six years of groundwork, has, with the help of radio jingles, TV spots and posters, already mustered wide support. All that it needs now are the rabbits to start the breeding.

...OUI MONSIEUR, BUGS BUNNY HIMSELF TODAY...

Newlove Mamattah, a former adult educator and the brain behind the rabbit breeding programme, considers rabbit breeding very attractive. A pair of them can yield meat equivalent to the weight of an entire cow, and that in the span of just one year. And all that rabbits need are: some grass, groundnut, sweet potato vines, dried cassava, sugarcane wastes and the brewer's mash.

Rabbit-breeding centres are being set up and the would-be breeders have to take a three-day intensive course in rabbit husbandry before purchasing a breeding stock. Now rabbits have not only cropped up on the school menu but also entered the curricula.

FATHERLESS OFFSPRING

This doesn't refer to orphaned offspring but to those who have never had any male parent. This phenomenon where non-fertilised eggs develop into embryos is called parthenogenesis. It can occur in certain insects, fish, reptiles and birds. Here the female generative cell, the egg cell, develops into a baby animal without being fertilised by the sperm—the result of such a reproduction is that the offspring are all always daughters.

Now Pierre Soupart, Vanderbilt University, Nashville, USA, has for the first time successfully induced parthenogenesis, up to the blastocyst stage, in a mammalian species—the laboratory mouse. He fused two egg cells by means of standard techniques and the resulting cell had the exact number of chromosomes as a fertilised egg. It even developed up to the 64-cell blastocyst stage.

If this technique can be perfected to yield fully developed young ones and extended to cattle, the breeders in the dairy industry would have realised their dream. That dream is to produce females only.

This egg and egg fusion came about when Soupart was studying the role of the sperm in fertilisation. The next step is to transfer the fused cell into a surrogate mother so that it can develop to maturity.

DRUG FROM URINE

When autourine therapists hear this, they'll probably jump and say excitedly "we told you so". Scientists of a Danish pharmaceutical company have found an anti-anxiety compound in human urine.

What prompted the search for this compound was the presence of receptors in the brain for benzodiazepine drugs which are used to control anxiety. As in the case of enkephalins, the body's natural opiates, this finding suggested that the body itself might make some anti-anxiety factor.

Claus Braestrup, head of the Danish research team, calls this compound a gamma substance. This substance has also been found in the brain tissue. Not wishing to reveal its identity for "patent reasons", Braestrup describes this as a lipophillic, aromatic compound of small molecular weight. Based on this description, there are speculations that this compound is similar to norepinphrine or serotonin which are derived from amino acids and serve as transmitters in the brain. At least, Solomon H. Snyder, the enkephalin man thinks so.

The pure gamma substance is said to be very active. It binds more strongly to receptors than even Valium (Valium and Librium are two benzodiazepine based drugs used commonly for anxiety states). The Danish scientists feel that this drug might act as a selective anticonvulsant or as an anti-anxiety drug. It would probably be without any of the side-effects. Also it might bind specifically to the receptors.

Another important aspect is that the gamma substance might be able to explain how anxiety is mediated in the brain.

OIL REFINERIES MAKE RAIN

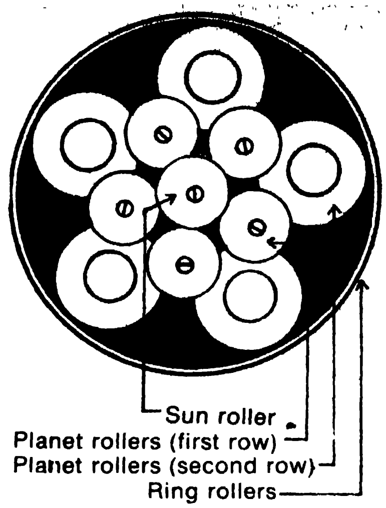
Only their rain is acidic. For rain to form, the water droplets in the cloud should coalesce to large drops. Clouds themselves form around airborne impurities called condensation nuclei.

Now, according to researchers from the National Oceanic and Atmospheric Administration, Boulder, USA, rain formation is determined by the type of nuclei. W.E. Barret, F. Parungo and R.F. Pueschel who studied the composition and size of the condensation nuclei found that oil refinery-polluted air contained many large droplets. In smog-polluted air the droplets are small. Refineries using nitrates and nitric acid yield better nuclei, but then these very chemicals make the rain acidic.

TOOTHLESS GEARS

Gears are toothed machine elements that are used to transmit motion between rotating shafts and for this the teeth on one shaft engage with corresponding wedges in the other shaft. So we can see that the teeth are the essential aspects. But they also present a few disadvantages. In high speed applications such as industrial grinders, gas turbines, millers, etc they become an expensive and unreliable option. Also, if the teeth are not precisely machined, noise becomes a major nuisance.

Eliminating the teeth could solve some problems. Though a toothless gear wheel sounds almost impossible, scientists at NASA's Lewis Research Center, Cleveland, USA, seem to have an answer. Patented by a private inventor and perfected by NASA's engineers, the system works in the same way as gravity. The NASA scientists have designed a toothless planetary gear system. (A planetary gear system consists of a central gear and a coaxial internal ring gear with one or more intermediate pinions supported on a revolving carrier. The central gear is called the sun roller, the surrounding intermediaries the planetary rollers and the ring, the planetary or roller ring.) The planetary ring squeezes on the planet rollers pressing them on to the central roller. This causes the rollers to engage in a friction or traction grip.



Tests with the toothless rollers show that the system is as good as the toothed gears in efficiency and is capable of reducing drive speeds by ratios more than 15 to 1. The system is expected to cost less, weigh less and produce much less noise. Its drawbacks: the rollers are more difficult to lubricate and the area in contact is greater than in toothed wheels since a continuous surface is in contact between the wheels. The result is higher friction-induced heat and greater wear. The NASA team believes that oiling with a specially developed lubricant called cyclo-aliphatic hydrocarbon which has a high coefficient of friction will solve the problem.

SOLAR ENERGY FROM OCEANS

The sun's energy stored in warm surface waters of the ocean is now generating about 50 kilowatts of electricity in a first-of-its-kind power plant located off the Kona coast of the Island of Hawaii.

The plant has operated successfully for several days and demonstrated that Ocean Thermal Energy Conversion (OTEC) is a feasible source of power. The successful demonstration plant is called mini-OTEC because it generates only 50 kilowatts.

About 40 kilowatts of the power the mini-OTEC generates is used to operate the system itself, and the 10-kilowatt surplus is used to power the test and measurement equipment. In an advanced, fully-operating system a much smaller proportion of the balance would be available for useful work.

The OTEC concept is nearly 100 years old, but the low cost of fossil fuel and the abundance of hydro-electric power had been competitive so far. But with the energy crisis, mini-OTEC could be the forerunner of huge, commercial, floating power plants.

This is how the system works: the warm surface water, with temperatures

TUBOPONICS: A MULTISTOREY GARDEN

From the land that specialises in desert agriculture comes a new method of growing plants with minimum water. The method is based on an age-old practice called the barrel agriculture where a barrel was filled with soil, holes were drilled along its sides and in each hole one plant was grown. What Tuvyia Spector at Israel's Volcanic Centre for Agricultural Research has done is to substitute the barrel with a vertical aluminium tube.

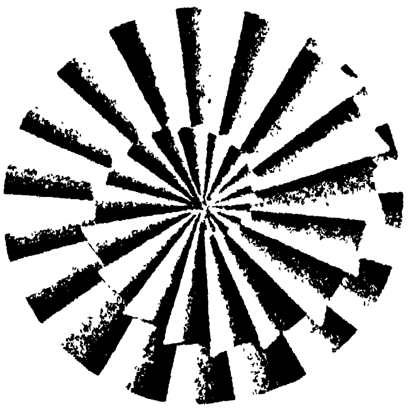
The tube is about 1.2 to 2.4 m long and filled with peat and volcanic ash. Terraced along its sides are openings to hold plants. The tube is made to stand on one of its rims and water and liquid fertilisers are control-dripped from above. The advantage here is that the water and nutrients that bypass the upper plants are used up by the ones below, thus minimising waste.

At the Volcanic Centre, cucumbers strawberries, cabbages and several lush house plants can be seen growing one atop another. The tomato yield, it is said, has been remarkable. The Ministry of Agriculture has now sanctioned funds for systematic analysis and perfection of this multilayer hydroponic system.

ranging from 24 to 28°C, is pumped through a heat exchanger to vapourise a low boiling point liquid such as ammonia. This is used to power a turbine and generate electricity. Cold water at 5°C pumped up from depths of about one km passes through another heat exchanger, which condenses the ammonia vapour back to a liquid. A one km 61-cm diameter polyethylene pipe is used to bring up the cold water. Thus ammonia, which is contained in a closed loop, keeps repeating this cycle.

SEEING IS GENETIC

How do you perceive the accompanying sketch? Look at it from the corner of your eye. Does it appear static or does it rotate? Some 75 per cent of the people asked this question said, they saw it rotating. To the rest it appeared static. The experiment conducted by Alex Fraser and Kimerly Wilcox of the Department of Biological Sciences, Cincinnati, Ohio, USA, was intriguing. The experimenters wondered why people's reaction varied.



Most of the experimental subjects were university students and teachers. A majority of the fine arts students, 95 per cent, visualised movement. Among psychologists the movement viewers were 50 per cent and among biologists, they formed 25 per cent.

Could this varied response have a genetic origin? Fraser and Wilcox checked the responses of parents and children and pairs of identical twins and this confirmed their hunch—genetic factors were at work.

THE ORGANIC HUES OF JUPITER

What makes the Jupiter's Red Spot red! It was hypothesised that the photolysis of phosphine into red phosphorus was responsible. That's not correct, according to Dr. Cyril Ponnamperuma, of the University of Maryland, USA, because there is acetylene in the Jovian atmosphere and this would prevent photolysis.

Ponnamperuma and his associates simulated the Jovian atmosphere. They exposed the model atmosphere to UV light and electric discharge and studied the photochemical reactions. They found that organic compounds caused the various hues.

Organic tar was ubiquitous. It condensed on the walls of all the apparatus. Analysis showed that the tar was made up of mixtures of compounds with molecular features of every possible chemical combination of carbon, hydrogen and nitrogen. There were aromatic and heterocyclic aromatic compounds and ionic combinations of hydrogen cyanide and amine nitrogen. These were yellow when fresh and turned brown on aging.

The Maryland team feels that yellow Jovian bands are made of fresh organic tar formed by upwelling gases from the lower atmosphere. The brown bands are aged tar which undergoes intramolecular condensation before sinking back into the atmosphere. The red spots—including the 300-year-old Great Red Spot—are cyclonic mixing of new and aged tar. Blue bands, they say, are due to light scattering. White regions between the yellow and brown are frozen ammonia and/or water. At first, it was thought that the large amount of hydrogen in the Jovian atmosphere would inhibit photochemical synthesis of organic compounds. The atmosphere consists of almost 89 per cent hydrogen, 11 per cent helium with traces of water, methane, phosphine, ammonia and germane. The distribution of these compound types remained the same even at lower concentrations. In fact, these compounds enhanced the photoconversion of methane.

LOVE IS . . . A QUESTION OF TEMPERATURE

For a happy marriage, they say the partners should match temperamentally. Orthodox people put their trust in horoscopes. The mod generation prefers to test their compatibility by performing the experiment in natural conditions—by living together. After studying a group of middle class couples in the mid-30's a New York University psychologist has come up with a new suggestion on how to judge whether the partners are made for each other.

According to Carol Noll Hoskins, all you need is a simple clinical thermometer. In her study of the married couples, who had been married for about eight and half years, Hoskins found happy couples had matching temperatures.

For six days during the study period, the couples recorded their temperature during every waking hour. (The body temperature follows a 24-hour rhythm.) Every four hours, they filled up a form designed to gauge levels of psychological activation. And twice a day, they filled in forms listing out their interactions with their spouses.

Hoskins' data showed that temperature synchrony was linked with cordial relationship. In strained relationships she found that there was no significant circadian rhythm in temperature fluctuations of the individuals. Of course, there is a possibility that this irregularity might be a result of stressful conditions.

THE YEAR OF THE RHINO

The year of the child, 1979, had also been declared the year of the rhino. Yes, it is the pachyderm we are talking of. There are five species of rhinoceros: the black rhino, the white rhino which is really grey (both African), the Indian rhino, the Javan rhino and the Sumatran rhino.

The rhinos have been martyrs to superstitions. The medicinal and tonic properties ascribed to the various parts of its body and especially to its horn have spelled the doom of the creature. The horn being small and easy to hide is a major coming-of-age gift to young boys in the Middle East because of its supposed aphrodisiac qualities and phallic appearance. They are used mainly as dagger handles. An elegantly carved one can cost up to US $ 12,000

That the rhino was depleting so fast became obvious when IUCN's experts were counting elephants. The extent of depletion prompted World Wildlife Fund to shelve all other projects and take up the rhino problem instead. It has been found that the animals are being killed at the rate of one per day in Tanzania. In Kenya, Somalian raiders have a field day.

M.L. Talbot, an ecologist who has studied all five rhino species in their native environment, is hopeful of saving all but the Sumatran species. Meanwhile, he has maintained an open mind on the various superstitions. Several Swiss pharmaceutical firms are looking into the truth behind the superstitions.

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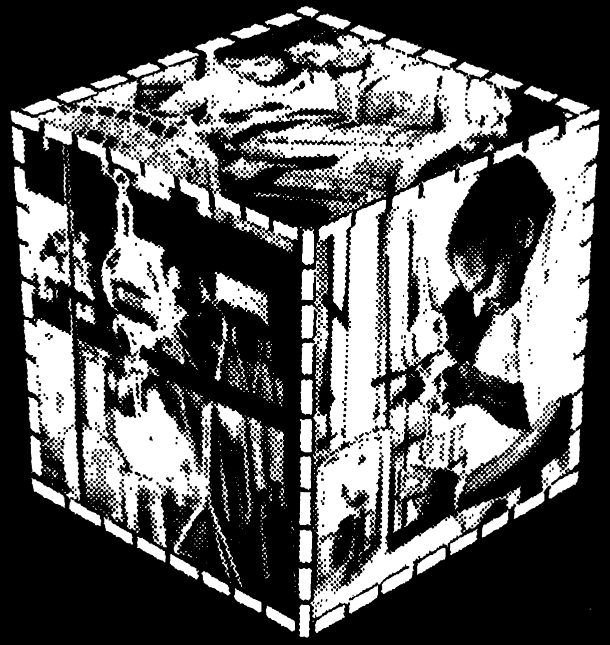

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COMPRESSION due to overhigh stacks and improper slinging.	Make sure of adequate rigidity in packaging materials. Lighter packages should be stacked above heavier ones. Mark permissible stack heights on packages.
CORROSION from humidity and temperature changes.	Use barrier materials, dehydrants and corrosion preventive coatings on metal components.

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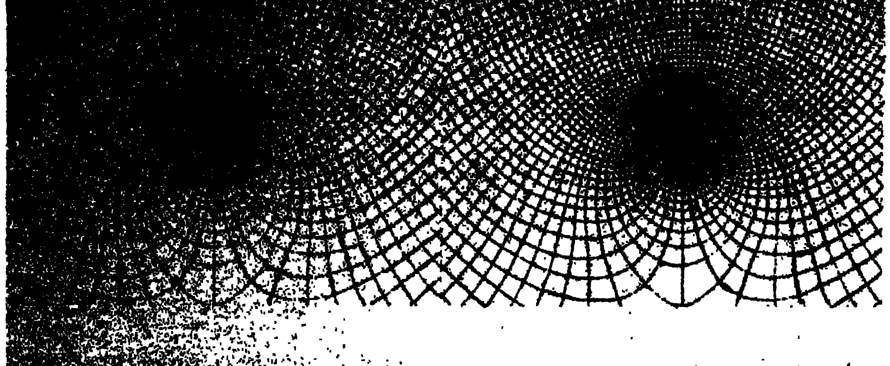
CASLPA-18-254

Basic forces of nature and their unification

Virendra Singh



There are four kinds of basic forces in nature—the gravitational, the electromagnetic and the weak and the strong. Scientists have long tried to determine their inter-relationships and unify them within a single framework. Though the final goal is still elusive, some recent work has taken the quest a step ahead. The first of this two-part review discusses the earlier works of Newton, Faraday and Maxwell in discovering the gravitational and electromagnetic forces. Incidentally, last year was the death centenary of Maxwell who had proposed the unified theory of electric and magnetic forces.
The second part will deal with the recent works of unification of electromagnetism with weak forces. It was for this work that the 1979 Nobel prizes for physics were given to Sheldon Glashow, Steven Weinberg and Abdus Salam

IN THE last century, P.G. Tait, an English scientist, introduced an ideal physicist in his book *Paradoxical Philosophy*, and named him Herman Stoff Kraft using the German words for matter (stoff) and force (kraft). This was rather appropriate, as the Newtonian conception of the universe was that of matter moving under the action of specified mutual forces. Matter was generally regarded as "atomistic", being composed of a set of "mass-points" (that is, point particles endowed with mass). The entire motion of these mass-points was predictable, using Newton's laws of motion, if one knew the forces operating between them and their positions and velocities at any instant of time.

What then are these forces of nature? One of these forces, that of gravitation, was identified by Isaac Newton in the 1680's. His *Philosophiae Naturalis Principia Mathematica*, published in 1687, marks the watershed between medieval and modern views of the world. In medieval times, it was generally believed that the laws that governed celestial objects must be different from those that governed terrestrial objects, since things are perfect and permanent in the sky while they are imperfect and subject to decay on the earth. Astronomy and physics were thus totally different sciences. One of Newton's major achievements was to bring astronomy into the fold of physics. He showed that the same law of gravitation which applied to apples falling to the ground, or ocean tides, also applied to the heavens and kept the moon in orbit around the earth and the earth around the sun.

Newton proposed that *any* two mass-points attract each other with a force which decreases with the square of the distance between the two mass-points. Further, the force is proportional to the product of their masses. The magnitude of this force is measured by the value of Newton's gravitational constant. Note that, unlike other forces which we will come across later, this force operates between any two particles and is thus *universal*. In fact, this universal character is the reason why the gravitational force dominates all largescale phenomena, despite the intrinsic smallness of the gravitational constant compared with other forces.

The mathematical difficulties of calculating the gravitational forces between real bodies like the sun and the earth or the earth and the moon, given the above law of gravitational force between any two mass-points, were overcome by Newton in 1685 after a long period of hard work. The final solution was elegant and simple. He showed that it was mathematically correct to treat spherical bodies as mass-points with the total mass of the body located at the centre of mass. Mass density variations inside the body did not affect the result. It was now easy for Newton to work out a dynamical theory of planetary motion and explain Kepler's laws. Indeed, our present understanding of the trajectories of planets or of satellites, except for tiny general relativistic effects, is entirely based on Newton's theory of gravitation.

Are there any other forces in nature? The property of lodestone to attract pieces of iron and of amber to attract small pieces of matter on rubbing were known to the ancient Greeks. In fact, the English words 'magnetism' and 'electricity' derive respectively from the Greek words 'magnetis lithos' for stone of magnesia and 'elektron' for amber.

Magnetic force

In the thirteenth century, Pierre de Maricourt, a French crusader, carried out experiments with a spherical lodestone. He placed an iron needle on the surface of the lodestone and marked the direction pointed out by the needle. He found that lines obtained by connecting these needle directions are closed and, what is more, they all pass through two points on the surface of the spherical lodestone. This was similar to the geographical situation on the earth, where all the meridians of longitude on the globe are closed and all pass through two points on the globe, the geographical north and south poles. He, therefore, proposed to call the corresponding points on the spherical lodestone magnetic north and south poles.

A great advance in the study of magnetic phenomenon was made by William Gilbert of England, when he published *De Magnete* in 1600. Gilbert was royal physician to Queen Elizabeth, which gave him a high contemporary social standing, but today his fame derives from his scientific works. He observed that the earth itself acts as a magnet and it's two magnetic poles are located close to it's two geographical poles. He also enunciated the general law that two like magnetic poles of any two magnets repel each other while unlike ones attract each other. He even speculated that the magnetic force exerted by the earth was responsible for its gravity. This attempt at the unification of gravitational and magnetic forces was a forerunner of all such later attempts, for example, Einstein's lifelong quest for a unified field theory.

The inverse square law of force between magnetic poles was discovered by John Michell who published *A Treatise of Artificial Magnets* in 1750. He wrote: "Wherever any magnetism is found, whether in the magnet itself or any piece of iron, etc excited by the magnet, there are always found two poles, which are generally called north and south, and the north pole of one magnet always attracts the south pole, and repels the north pole of another, and vice versa... Each pole attracts or repels exactly equally, at equal distances, in every direction... The magnetical attraction and repulsion are exactly equal to each other... The attraction and repulsion of magnets decrease, as the square of the distances from the respective poles increases." Note that a north magnetic pole is always found with a south magnetic pole and never by itself. The magnetic poles are thus confined.

Electrical forces

In contrast to the study of magnetism, progress in the study of electrical phenomenon was slow. It was sometime before it was realised that amber, which electrified substances on rubbing with it, shared this property with many other materials. C.F. du Fay, in order to account for his various observations involving electrified bodies, introduced the two fluid theory of electricity in 1734 and gave the name vitreous and resinous electricity to them. He noted: "We see then, that there are two electricities of a totally different nature—namely. that of transparent solids, such as glass and crystal, and that of bituminous or resinous bodies, such as amber, copal, and sealing wax. Each of them repels bodies which have contracted an electricity of the same nature as its own, and attracts those whose electricity is of the contrary nature. We see even that the bodies which are not themselves electrics can acquire either of these electricities, and that then these effects are similar to those of the bodies which have communicated it to them."

Isaac Newton

The next great electrician—to use nineteenth century terminology—was Benjamin Franklin of the USA. His researches began around 1747, and he was the first to recognise the conservation law of electric charge. He showed that while rubbing two substances to produce electrification, the amount of electric charge gained by one was the same as that lost by the other. There is no creation of electric charge but only a transference. In Franklin's view, the resinous electricity is nothing but a deficiency of vitreous electricity in a substance and he proposed to assign positive electric charge to vitreous and negative electric charge to resinous electricity. He also showed in his famous kite-flying experiment, in which he drew lightning discharge from the clouds, that lightning is electrical in nature and used this knowledge for inventing lightning conductors.

The precise law of force between electric charges was conjectured in 1767 by Joseph Priestley—better known for his discovery of oxygen—who postulated that forces between electric charges also obeyed the inverse square law with distance, just as did the gravitational force and the magnetic force between two magnetic poles. His conjecture was based on the lack of electric force inside an electrically charged hollow metal sphere. Though this conjecture was given direct experimental support in 1771 by Henry Cavendish, an eccentric English millionaire savant, he did not bother to publish it. The credit, therefore, for establishing the inverse square law for electric forces goes to Charles A. Coulomb, who demonstrated it experimentally in 1785, using a precision torsion balance for this purpose.

Chemical affinity and electric forces

The electrical experiments discussed so far all involve static electricity, or where electric charges are stationary. The experiments involving electric charges in motion, or those involving electric currents, became possible after the discovery of the first electric battery, called the Voltaic pile after its discoverer Alessandro Volta of Italy. Volta wrote in 1799: "The contact of different conductors, particularly the metallic, including pyrites and other minerals, as well as charcoal, which I call dry conductors, or conductors of the *first class*, with moist conductors, or conductors of the *second class*, agitates or disturbs the electric fluid, or gives it a certain impulse."

It was soon found that an electric current passing through various substances leads to their decomposition. Thus water is decomposed into hydrogen and oxygen gas. This was the beginning of electrochemistry in the hands of Sir Humphrey Davy. These studies strongly indicated that chemical affinity, or forces which bind atoms and molecules together, are electrical in nature. It is thus seen that just as tidal forces are an expression of basic gravitational forces, the chemical forces responsible for various kinds of chemical binding are an expression of basic electrical forces.

A quantitative understanding of this unification of chemical and electric forces of nature had, of course, to wait till quantum mechanics was developed and was first indicated in the work of W. Heitler and London.

Action-at-a-distance

Thus the picture that emerges is the one in which any two point particles exerting on each other gravitational, electric and magnetic forces without any intermediary. We can thus say that these are "action-at-a-distance" theories. All these forces decrease according to the inverse square of the distance. If the mass is regarded as a "gravitational charge," the gravitational force is attractive between two like charges, while the other two

Michael Faraday and his wife

forces are repulsive between two like charges and attractive between unlike charges.

When Newton had proposed his theory of gravitational force he had put it up purely as a phenomenological proposal. Initially this "action-at-a-distance" aspect of Newton's theory was found repugnant and akin to magic by a number of people such as Descartes. After all, how can a particle affect another one far away where it is not? Gradually, however, Newton's theory came to be looked upon as an ideal model of a theory to be emulated by other theories. Was not Newton's theory resoundingly successful in celestial mechanics? It was, therefore, found gratifying that both Michell's law for magnetic forces and Coulomb's law for electric forces were of the "action-at-a-distance" type.

As a result of further work leading to the unification of electricity and magnetism, in other words, to electromagnetism, the "action-at-a-distance" concept was to receive a severe jolt.

Unification of electric and magnetic forces

The first person to demonstrate an undeniable relationship between electricity and magnetism was the Danish physicist H. C. Oersted. He found in 1820 that an electric current exerts a force on a magnetic needle placed parallel to it. The magnetic needle is seen to undergo a marked deflection. In his previous experiments he had placed the magnetic needle perpendicular to the current-carrying wire and had observed no effect. The exact laws for the force between the magnetic and small current elements were investigated by J. P. Biot and Felin Savart.

Ampere then investigated the forces exerted by two current-carrying wires on each other. He found that if two wires are parallel, they attract or repel each other depending on whether the currents are passing through them in the same or opposite direction. Such an experimental effect was unexpected, since, after all, a magnet attracts an iron piece but two iron pieces do not display any mutual attraction. The brilliant mathematical analysis of these experiments by Ampere, during 1822-27, led to the result that in its magnetic effects, an electric current is equivalent to a magnetic shell. In view of these results, he proposed that magnetism is really due to small, electric current loops present in magnetic materials. Basically, our modern understanding of magnetism is based on this hypothesis of Ampere and these small current loops are today identified with the motion of electrons. Besides, the electron itself has been found to behave like a tiny magnet.

Faraday's drawings of lines of magnetic force as delineated by iron filings (*Philosophic Transactions*, 1852)

The converse effect to Ampere's discovery, whether a magnet can behave like an electric current, was looked for by Michael Faraday. At first he tried to look for an electric current in a conducting wire by placing a magnet near it. This attempt failed, and no current was produced. He came back to this problem after a few years of chemical investigations in 1831. This time, on the analogy of electrostatic induction, he investigated whether any electric currents are induced in a neighbouring electric circuit by a current-carrying conductor. He did find induced currents but, to his surprise, these were only present in the secondary circuit either when the primary electric circuit was being closed or being broken. The steady electric current in the first circuit had no effect on the secondary circuit. He was clearly on to something.

In the crowning experiment of this series, Faraday wound a copper wire around a hollow cylinder and connected the two ends to a galvanometer. A small cylindrical magnet was inserted quickly into the hollow cylinder inside the coil. As long as the magnet was moving, an electric current was produced in the copper coil. This was indicated by the deflection of the galvanometer needle. The current stopped flowing when the magnet came to rest in the coil and flowed in an opposite direction when the magnet was withdrawn. The same effect was produced when the coil was moved but the magnet was kept stationary. What mattered was the relative motion between the coil and the magnet.

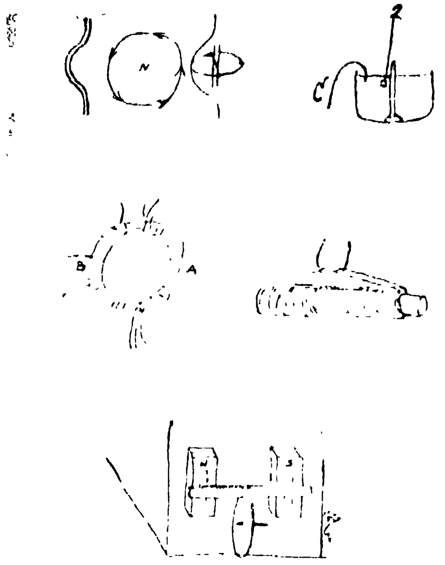
Faraday had thus discovered the laws of electromagnetic induction which laid the foundation for the entire industry of electrical power generation. He had also established the unity between electric and magnetic effects.

Electromagnetic field

Faraday had equipped himself by reading books which came for binding to the shop where he began life as a bookbinder's assistant. He escaped the grinding of a regular university education. To somebody else not so superbly endowed with physical intuition, it might have been a handicap but to him it proved a blessing as he could think in new fruitful ways, unmindful of breaking the "action-at-a-distance-force" mould.

Discovering the laws of electromagnetic induction was not enough for Faraday. He had to 'understand' these results and he came up with the following physical model. He found the clue in the old practice of exhibiting the effect of a magnetic force by strewing iron filings around a magnet. The iron filings arrange themselves in closed curves. For example, if one drops iron filings onto a glass plate perpendicular to a current-carrying wire, the iron filings arrange themselves in concentric circles around the wire. To Faraday, these curves suggested the idea that the whole of space is filled with these invisible lines and they indicate the direction of magnetic force. Further, he assumed that their density at any place is a measure of the intensity of the magnetic force. A similar picture also applied to electric forces. With these ideas of lines of force, it was easy for him to visualise what was happening in electromagnetic induction. What caused the induced current was the cutting of magnetic lines of force by the electric conductor. Clearly, the faster the relative motion, the greater the number of magnetic lines of force cut, and therefore the stronger the electric current in the conductor.

As Faraday noted: "In this view of the magnet, the medium or space around it is as essential as the magnet itself, being part of the true and complete magnetic system." Thus was introduced



Sketches from Faraday's diary show the progression of his electromagnetic experiments. The sketch at top left shows how he bent a wire conductor into a curve, floating one end on a cork in mercury, then put a bar magnet in the curve, causing the wire to swivel around it, in the first demonstration of electromagnetic rotation. He next fixed the magnet upright in a bowl of mercury, as shown in the sketch at top right, to allow the floating conductor to revolve completely around it — the principle of the electric motor. In 1831, winding two coils of wire A and B on an iron ring and connecting A with a battery, as shown in the sketch at middle left, he caused an intermittent current to flow in B, thus discovering electrical induction. By plunging a magnet in and out of a hollow cylinder and coil connected to a galvanometer (middle right), he showed that current may be induced by the relative motion of a conductor and a magnetic field — the principle of the electric generator. The sketch at the bottom shows how Faraday rotated a copper disc between the poles of the Royal Society's compound magnet, thereby inducing a continuous current — the birth of the dynamo *(Lives in Science)*

the concept of field theory. In this picture we assign an electric field and a magnetic field at each point of the space-time continuum. These fields are produced by the electric charges and electric currents (that is, electric charges in rest and motion) and they interact with other electric charges and currents. The interaction depends only on the value of electric and magnetic fields at the position of the affected electric charge. All interactions involving electric and magnetic forces are thus local interactions. There is no "action-at-a-distance". In a letter to Richard Taylor in 1844 he quoted the old adage, "Matter cannot act where it is not". He was also in favour of introducing a gravitational field to understand gravitational forces.

Faraday's views, which were expressed without using mathematical symbols, were generally not understood by a generation of physicists raised on "action-at-a-distance" theories. However, they appealed to James Clerk Maxwell, who was able to fathom their meaning. He wrote: "As I proceeded with the study of Faraday, I perceived that his method of conceiving the phenomena was also a mathematical one, though not exhibited in the conventional form of mathematical symbols... Faraday's method resembled those in which we begin with the whole and arrive at the parts by analysis, while the ordinary mathematical methods were founded on the principle of beginning with the parts and building the whole by synthesis."

Maxwell undertook a study of the physical nature of fields postulated by Faraday. He also wanted to give mathematical precision to these ideas and in this he was eminently successful. In his first paper *On Faraday's Lines of Force* (1856) on the subject, he constructed a hydrodynamical model for lines of force. The electric field was taken to be given by the shape and size of the tubes of electric fluid considered incompressible. This way, he was able to account for various electrical observations.

In his second memoir *On Physical Lines of Force* (1861-62), Maxwell extended his considerations to give a mechanical model of electric and magnetic fields. Following W. Thomson, he was convinced that the nature of magnetism is that of a rotation. He wrote: "The transference of electrolytes in fixed directions by the electric current, and the rotation of polarised light in fixed directions by magnetic force are the facts, the consideration of which has induced me to regard magnetism as a phenomenon of rotation, and electric currents as a phenomenon of translation." A constant magnetic field pointing in a fixed direction was represented by a cylinder rotating at a constant velocity with axes parallel to the fixed direction. However, in order that all the cylinders could rotate in the same direction he had to introduce rows of small spheres between the cylinders to act as gears. The mathematics then led him to the conclusion that if the flux of these small spheres represents electric current, then one can account for the phenomenon, observed by Oersted, that the magnetic field acts in a direction perpendicular to that of the flow of electric current. The small spheres can thus be viewed as electrically charged particles.

Maxwell now displayed that special flash of genius which transforms a subject. It was his conception of displacement current. When one applies an electric field to a dielectric, then, in Faraday's conception of dielectric, which was that of small conductors embedded inside an insulator, the electric charge on each small conductor is displaced. This movement of electric charges, which is there as long as electric field is varied, is to be regarded as an electric current. From this, Maxwell abstracted the idea that all variations of displacements are equivalent to an electric current. He also asserted that a displacement is there simply by virtue of the presence of an electric field even in the absence of dielectrics. This had far-reaching consequences.

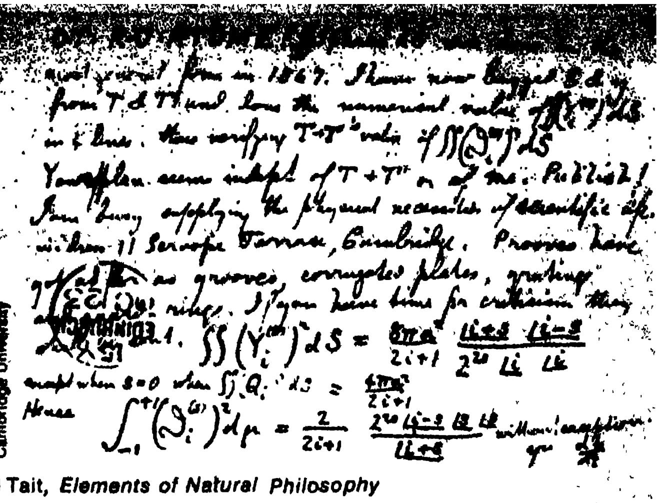
His final version was given in 1864 in his memoir *A Dynamical Theory of Electromagnetic Field.* Here one finally has the system of equations for the electromagnetic field, now known as Maxwell's equations, without any of those crutches, like rotating cylinders, ball bearings and so on, which were used to obtain them. This whole process of mathematical abstraction has been likened to the process of the Cheshire cat grin surviving the disappearance of the cat in Lewis Carroll's *Alice in Wonderland.*

Thus, Faraday's and Maxwell's works brought about a change of viewpoint in the conception of force. In this approach, the interaction of two charged bodies was not regarded as due to something called "force" by which they could affect each other instantaneously over arbitrarily large distances. Rather, a charged particle produced an electromagnetic field and was acted upon by the electromagnetic field which was an entity in it's own right. The deeper concept now is not that of force between two electric charges but rather, the interaction energy between a given electric charge-current distribution and electro-magnetic field. Indeed we

James Clerk Maxwell

should have more aptly used the word "interactions" instead of "forces" in the title of this article. The word "forces", however, has been retained there so that one can begin with a generally understood word.

In fairness to Newton, one must however, point out that he himself had qualms about "action-at-a-distance" and had proposed it only as a purely phenomenological description. He himself once noted "that one body may act upon another at a distance through a vacuum, without the mediation of anything else, is to me so great an absurdity that I believe no man, who has in philosophical matters a competent faculty for thinking, can ever fall into."


Cambridge University

[illegible] postcards sent by Maxwell to his friend Peter Guthrie Tait. William Thomson (Lord Kelvin) is referred to as T, P.G. Tait as T', and Maxwell signs himself dp/dT in accordance with the thermodynamic relation dp/dT = JCM. The term T & T' used in lines 3 and 4 refers to the famous nineteenth century text by Thomson and Tait, *Elements of Natural Philosophy*

Electromagnetic radiation

A remarkable prediction of Maxwell's eqtiations was that the discharge of an electric condenser was not an instantaneous phenomenon but rather an oscillatory one. During this process waves are generated in which electric and magnetic field vectors oscillate and remain perpendicular to each other as well as to the direction of propagation of the waves. Maxwell calculated the velocity of these waves and found it to be given by the constant c, which occurred in the change of units from an electrostatic to an electrodynamic system. This constant had been measured earlier by Friedrich Kohlrausch and Wilhelm Weber and it's value had been found to be 3.10×10^{10} cm per second in 1849. This agreed rather well with the determination of the velocity of light by Fizeau who obtained a value of 3.5×10^{10} cm per second. The natural and bold conclusion drawn by Maxwell was: "We can scarcely avoid the inference that light consists in the transverse undulations of the same medium which is the cause of electric and magnetic phenomena." The medium was called luminiferous ether in nineteenth century physics and was postulated as "the material" which oscillates and was discarded from physics only after Einstein's special theory of relativity made it superfluous.

Thus the unification of electricity and magnetism resulted not only in providing us with a better understanding of these phenomena but also reduced optics to a branch of electromagnetic theory and showed that visible light is nothing but electromagnetic waves with wavelengths lying in the range 4000 to 8000 Angstroms (1 Angstrom $=10^{-8}$ cm). All our present long-distance communications using radio waves and microwaves have flowed from this discovery of Maxwell.

[illegible] of the century it appeared that classical physics had reached a perfection and only the details remained to be filled. The electromagnetic theory of light was enormously successful in dealing with a wide range of phenomena involving light. It's first failure was it's inability to solve the problem of energy distribution of blackbody radiation. It was in this context that Max Planck introduced the quantum theory in 1900 and caused a revolution in physics.

In a number of phenomena involving interaction of light with matter, such as photoelectric effect and Compton effect, the observed behaviour was more consistent with a particle description than with a wave picture. According to the light quantum hypothesis of Einstein, light consists of particles called photons travelling with velocity c in straight lines with an energy $h\nu$ and momentum $h\nu/c$ for light with frequency ν. Here h is the Planck's constant. It was all very puzzling as light behaved sometimes as a wave phenomena and sometimes as a particle.

The final resolution of these was achieved when P.A.M. Dirac gave a quantum theory of the electromagnetic Maxwell field. It turned out that the wave and particle are complementary descriptions of the quantised electromagnetic field. It was further shown by Dirac (1927) that in quantum theory the electromagnetic interactions can be regarded as arising out of the exchange of virtual photons between charged particles.

Thus, in quantum theory the distinction between particle and field disappears. Photons are the particle aspects of the electromagnetic field. Charged particles also have a field description.

An immediate consequence of the quantum theory of interactions is that the range R of the interactions is given by the Compton wavelength of the exchanged particle (mass m), $R=h/mc$. Thus the infinite range of the electromagnetic interaction is correlatec with the photon mass being zero. Calling gravitational field quanta, gravitons, one would expect them also to have zero mass. Further, in quantum theory, one only has probability amplitudes and thus the fundamental question for the quantum theory of interaction would be to know the structure and magnitude of these amplitudes. For quantum electrodynamics, the strength of the probability amplitude for the basic process, charged particle→charged particle+photon, is controlled by the fine structure constant given by $e^2/\hbar c = 1/137$ where e is the electronic charge, and thus called the coupling constant. The structure of the amplitude involves only the electromagnetic current of the charged particle field as far as charged particle is concerned.

Quantum electrodynamics has been the most successful theory predicting results agreeing with experiments to an uncanny degree of accuracy. It has, therefore, continued to serve as a prototype of further developments. The genius of Maxwell comes through vividly when we note that his equations of electromagnetic field theory have come out unscathed through the twin revolutions of the relativity theory and quantum mechanics. One might even say that they were responsible for them. Even more remarkable, some of the formal symmetries of Maxwell's equation, such as local gauge invariance, have been crucial in recent efforts to understand and possibly unify other basic interactions of nature.

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The cosmic microwave background

MATTER in the universe is known to be divided into large collections of stars called galaxies. Cosmologists look upon the universe as a single system and attempt to study its structure and evolution.

It is known from observations that the galaxies are distributed rather uniformly in the universe. Another very important observation is that the universe is expanding. This means that the galaxies are all moving away from each other; and as time passes, a region containing a fixed number of galaxies gets bigger and bigger.

With the help of the above observations, and well known physical laws, cosmologists of the Big Bang school deduce that the universe came into being in a gigantic explosion about 10 billion years ago. In the moments immediately following the explosion, it was in a very dense state, with all the matter closely packed together. The matter existed as elementary particles and was very hot. The temperature was as high as a million million degrees Kelvin about one-hundredth of a second after the Big Bang. There was also electromagnetic radiation present, and continuous and rapid exchange of energy between the matter and radiation ensured that both had the same temperature.

The hot universe expanded continuously, and as it expanded it cooled. Two hundred thousand years after the Big Bang, the temperature dropped to about 4000°Kelvin. At this time most of the matter existed as hydrogen, and it did not exchange energy with the radiation. The radiation expanded freely and cooled, and has at the present moment the temperature of a few degrees Kelvin.

The Big Bang theory is no doubt very fascinating, but do we have any observational evidence that it is correct, at least in its essentials? A good piece of evidence can be provided by the relic radiation of the 'primeval fireball' described above.

When radiation continuously exchanges energy with matter and is in equilibrium with it, the energy in the radiation is distributed amongst various wavelengths. The curve, which shows how the energy of equilibrium radiation is distributed, is said to have the Planck form. The exact shape of the curve depends only on the temperature, and one can be deduced from the other. Radiation in the universe, immediately after the Big Bang, does have the Planck form. Even when matter and radiation stop exchanging energy, the Planck form will remain unaltered, but the temperature of the radiation decreases inversely as the distance between galaxies. It is the task of the observational astronomer to see if radiation of this type is present, and if it is indeed present, to determine its temperature. But various objects in the universe produce radiation which can mask the presence of the relic radiation. Moreover, the relic radiation has to travel through the atmosphere of the earth before it reaches ground based or air-borne detectors, and it may be absorbed or distorted on the way.

The first hint that relic radiation was present came from the work of Penzias and Wilson in 1967. But it was only this year that the work of D. P. Woody and P. L. Richards (*Physical Review Letters* **42** 925), has established conclusively that radiation with a temperature of nearly 3° Kelvin is present. The detector used was flown to high altitudes with a balloon to minimise the effects of the atmosphere. The radiation detected is called the Cosmic Microwave Background (CMB) because of the wavelength region in which it now occurs, and because of its conjectured universal presence.

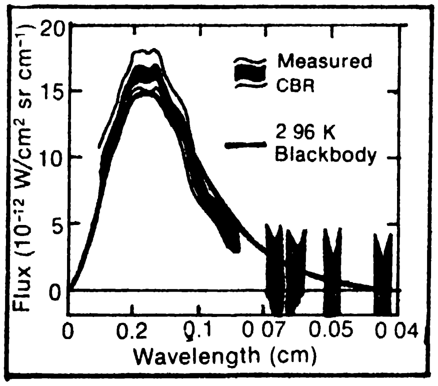

Fig.1 The shaded area shows the region in which the results of Woody and Richards lie. The dark curve is the ideal Planck curve for the temperature 2.96°K

The experiment which has confirmed that the radiation has approximately a Planck-like form has also raised new questions. The departures (Fig. 1) of the observed curve from the ideal curve are small but significant. No known process in the Big Bang picture can account for the observed departures from the ideal curve. Does this mean that the observed radiation is not a remnant of the primeval fireball?

In 1978, Martin Rees of Cambridge had come up with a plausible new mechanism for the CMB. He conjectured that in the early days of the universe, before galaxies were formed, a generation of stars called 'Population-III' was born. These stars emitted radiation which was absorbed by dust, the dust itself having been released by the Population-III stars. The dust was heated by the absorbtion of energy, and it emitted radiation which was now observed as the CMB Recent investigation by M. Rowan-Robinson, J. Negroponte and J. Silk (*Nature* **281** 635) has shown that the departures from the Planck law are best explained if the CMB is produced partly by the fireball and partly by Population-III and distorted by the dust.

If the CMB is of crucial importance in determining the history of the universe, it is also essential to determine conclusively its nature and origin. If indeed there is a contribution coming from Population-III, much of what has been deduced so far may have to be revised.

AJIT KEMBHAVI

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Effect of disuse on cerebellum

THE OVERALL wiring pattern of the animal brain is specified by its genes, but there is evidence that experience, particularly an experience of sensory or motor deprivation, can alter normal development. The classical experiments of Hubel and Wiesel on cats have shown that visual deprivation at an early stage leads to degeneration of neurons in specific regions of cortex.

So far studies of neuronal plasticity were restricted to the cortex. Although theoretical models of cerebellum, such as those developed by David Mar, postulate that learning of motor activity involves changes in cerebellar circuitry, there was no experimental evidence to support plasticity in cerebellum. Two recent papers (*Science* **206** p 227 and p 230) provide direct evidence of anatomical changes in the cerebellum of monkeys and mice as a result of "use and disuse".

From fish to man, the cerebellum, the lower and hinder part of the brain that is concerned with muscular coordination and maintenance of equilibrium, is rather similar. Phylogenetic stability of cerebellum, which is also known as the 'old brain', has reinforced the belief that it is hard-wired and cannot be modified by experience. The neurons of the cerebellum consist of five distinct cell types whose input-output connections are precisely defined.

The subject of the papers discussed here are the profusely branched Purkinje cells which form a distinct layer of cerebellum. At the University of Illinois, Floetter and

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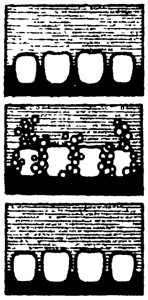

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Greenough, the authors of the first paper, reared macaque monkeys under three different conditions. The first group was kept in isolation in plexiglass cubes in a highly restricted sensory and motor environment. The second group was housed in wire cages under 'social' conditions. Cages for pairs of monkeys were adjacent and they were allowed four hours of play each day. The third group lived in a naturalistic setting in large rooms with other monkeys. They were given toys for exercise and play.

At eight months of age the Purkinje cells in different areas of the old brain in the three groups were compared by computer-aided microscopy. The cells of monkeys in the group reared in naturalistic conditions were larger and their synaptic connections were more complex. There was no significant difference in the Purkinje cells between the first two groups—the 'isolated' and the 'social' monkeys. Although the changes in 'linear extension' and spine density observed by Floetter and Greenough are small, they clearly demonstrate plasticity in the cerebellum. In other cell types such as granule cells no differences were seen.

Pysh and Weiss, the authors of the second paper, carried out a similar experiment with mice at Chicago. Two sets were compared, a physically active group raised in cages where the animals had ample opportunities for a variety of movements and an inactive group in which they were confined to small cages with severely restricted movements. An examination of Purkinje cells in the cerebellum showed that by several morphometric criteria—such as section area, dendritic field area, total branch length, spine density and number of spines—the neurons of inactive mice were 10 to 20 per cent less developed than the neurons of active mice.

The results of the two experiments are very similar. Floetter and Greenough conclude: "Plasticity in cerebellar circuitry indicates that phylogenetically stable structures as well as phylogenetically newer ones are not hard-wired and can be modified by environmental experience." Pysh and Weiss come to a more guarded conclusion. They point out that "even under conditions of severe functional motor deprivation, Purkinje cells are capable of developing most of their normal complement of dendritic spines". At the same time "physical motor activity and its concomitant, enhanced nervous activity, can produce a small but measurable alteration in the development of Purkinje cells". Whichever way one looks at the results, these experiments clearly establish the occurrence of plasticity in cerebellum and lend support to theories which implicate postnatal modifications in cerebral circuitry in the programming of learnt motor activity.

O. SIDDIQI

Professor Siddiqi is Head of the Molecular Biology Group, Tata Institute of Fun[illegible] Bombay.

Is the genetic code universal?

THE GENETIC information in DNA is expressed through the protein synthesising apparatus in all organisms. The genetic code was deduced from studies of a bacterial system, protein sequence analysis of mutant proteins from a plant virus and several mutant hemoglobins. And because of the remarkable constancy of the code words (or codons) in the systems studied, it was, in general, considered to be a universal code. Changes in the genetic code were expected to have deleterious effects on the organism. Recent work on the DNA sequence analysis has however brought out surprise in the otherwise universal code. Studies on the DNA sequence analysis of the gene for the enzyme cytochrome oxidase subunit II (CO II) isolated from yeast and human mitochondria show that one of the signals of chain termination during protein synthesis is interpreted differently.

...GGA TAT CAA TGA TAT TGA AAA TAT GAA TAT...
...CCT ATA GTT ACT ATA ACT TTT ATA GTT ATA...
DNA sequence

...GGA UAU CAA UGA UAU UGA AAA UAU GAA UAU...
mRNA sequence

gly-tyr-gln-trp--tyr-trp-lys-tyr-glu-tyr-
amino acid sequence

Fig.2 The nucleotide sequence of a part of the gene for yeast cytochrome oxidase subunit II along with the corresponding nucleic acid sequence of mRNA and the corresponding amino acid sequence in the protein

The genetic code consists of a three-letter code for each amino acid, with 64 possible code words arising out of the 3-letter combination of the four different nucleic acid bases, namely adenine, guanine, cytosine and uracil (thymine is found in place of uracil in DNA). Many experiments have demonstrated that all the codons are utilised, some more frequently than others. The start signal for protein synthesis is normally the methionine codon AUG, both in bacteria and in higher organisms. There are three termination codons, namely UAG, UAA and UGA, also termed amber, ochre and opal codons respectively. These three codons signal the end in the protein synthesis. They are also called nonsense codons because they represent combinations that are not code words for any amino acid, and thus make it impossible for a complete polypeptide chain to be formed.

The recent work of A. Tzagaloff and coworkers, Columbia University, New York (*Proceedings of the National Academy of Sciences, USA,* 76 3784) demonstrates that in the DNA sequence of yeast CO II gene, the sequence TGA, corresponding to the opal codon UGA, is found within the gene five times. It is surprising to find the termination codon in the middle of the gene sequence.

In fact, a comparison of the corresponding homologous amino acid sequence of the bovine protein with the DNA sequence of the gene shows that the amin acid tryptophan is inserted wherever ther is an opal codon (Fig.2). The norma tryptophan codon is UGG which differ from the opal codon UGA in the thir position.

Similar oddities were observed withi the CO II gene isolated from the huma mitochondria. Evidence similar to the CO gene is also accumulating from the DN sequence analysis of genes for two othe yeast mitochondrial proteins. Mitochondria are known to have their own protei synthesising machinery which is utilised i the expression of their genome. Does this mean that the mitochondrial protein synthesising machinery defies the universal genetic code? Or is it that the mitochondria have a unique species o transfer RNA (tRNA) which makes sense out of the nonsense codon? The latter possibility may be the real solution to this new riddle of mitochondrial goings-on. Already there is evidence in the bacterial system that a mutant or suppressor tRNA can accept and insert tryptophan in response to the UGA codon (albeit with lower efficiency). It has been found that there is indeed a gene for a tryptophan tRNA in human mitochondria which can recognise the UGA codon in addition to the normal UGG codon (an unpublished report). This observation would imply that the tryptophan tRNA could read two codons differing in the third position of the code word by a mechanism suggested by Crick as "wobble hypothesis".

The novelty of the mitochondrial genetic code seems to extend to other codons as well. The codon AUA which normally codes for isoleucine appears to be used in place of AUG for methionine in human mitochondria. There are other examples too. Is this to be considered a progress or a retrogress with respect to the established genetic code in bacteria as well as higher organisms? It has been speculated that the mitochondria in higher cells evolved as the result of a symbiotic union of bacteria with the cells from more evolved systems. It can be argued that the recent research on the genetic code stands against such a speculation. On the other hand, it is equally possible that the genetic code in mitochondria is a more primitive form of the universal genetic code.

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Alcohol from cassava

C. Balagopalan

N. Hrishi

Production of ethanol from cassava is one of the most efficient means of channelling solar energy to liquid energy

CASSAVA *(Manihot esculenta crantz)*, popularly known in India as tapioca, is one of the major tuber crops grown in more than 80 countries of the humid tropics. It is a high energy food obtained with low inputs and little effort. And to people in the tropics, it is either a main or a secondary staple food.

But there is another important role that cassava can play in the economies of the developing countries. Biological solar energy conversion by photosynthesis produces stored energy in the form of biomass, and the production of ethanol from cassava is one of the most efficient means of channelling solar energy to liquid energy. The high photosynthetic efficiency of cassava and the presence of a large quantity of fermentable sugars in the hydrolysed starch makes it an attractive source of renewable energy. As the price of crude oil and petrol continues to rise, alcohol from cassava will be more economical as an automobile fuel additive.

Cassava was introduced into India by the Portuguese in the 17th century. But it was Vishakham Tirunal, a ruler of the former Travancore State during the 18th century, who made it popular by introducing varieties from Malaya and other places. India now occupies the fifth place among cassava-producing countries of the world, the first four being Brazil, Zaire, Nigeria and Indonesia.

Today, cassava is mainly grown in India in Kerala, where it covers more than 0.39 million hectares with a production of 6.48 million tonnes. Kerala, in fact, has the monopoly of its cultivation, with 83 per cent of the total area under cassava cultivation in the country, and 88 per cent of the total production. Tamil Nadu follows with 13 per cent area and 9 per cent of the production. Karnataka, Andhra Pradesh and Pondicherry in the south and Assam, Meghalaya and Tripura in the north-east are the other states which grow cassava. Though the average yield of cassava in India is 16.60 tonnes per hectare, production goes up to 35 tonnes per hectare if high-yielding varieties are grown with proper agronomic practices.

Cassava is one of the most efficient photosynthesising plants known. It accumulates starch in large thickened storage roots (Fig.1), which contain 25 to 35 per cent of starch; on a dry weight basis, the starch content reaches up to 90 per cent. In terms of calories per unit land area per unit of time, its productivity appears to be significantly higher than that of other staple food crops. Cassava can produce 250 x 10 ^{3} calories per hectare per day compared to 176 x 10 ^{3} for rice and 110 x 10 ^{3} for wheat.

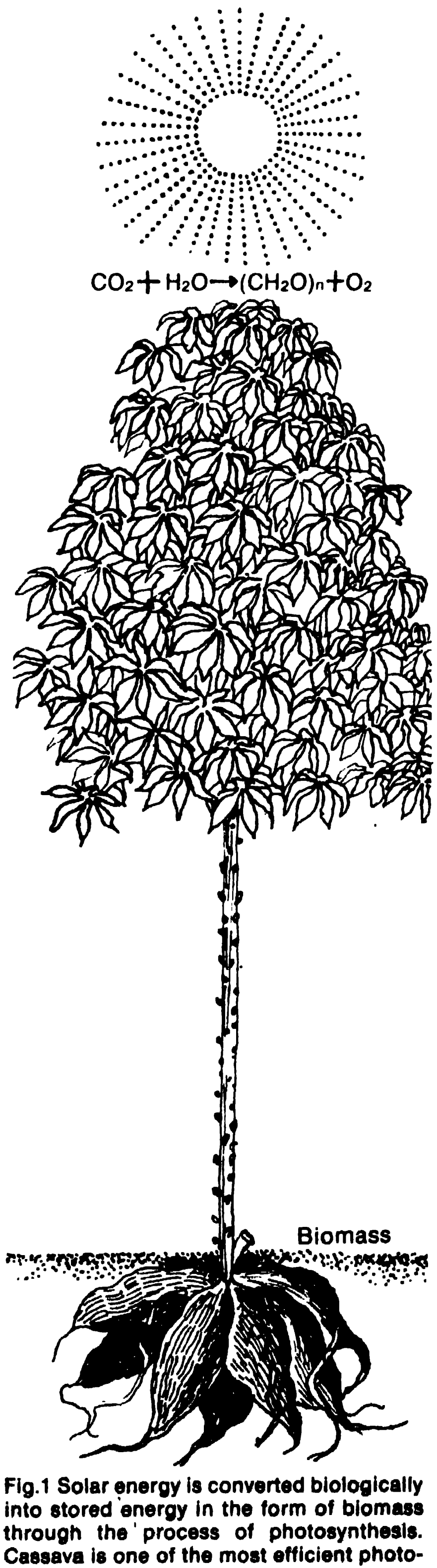

$CO_2 + H_2O \rightarrow (CH_2O)_n + O_2$
Biomass

Fig.1 Solar energy is converted biologically into stored energy in the form of biomass through the process of photosynthesis. Cassava is one of the most efficient photosynthesising plants. It is a slightly woody perennial shrub, reaching three metres

Biomass as a source of energy

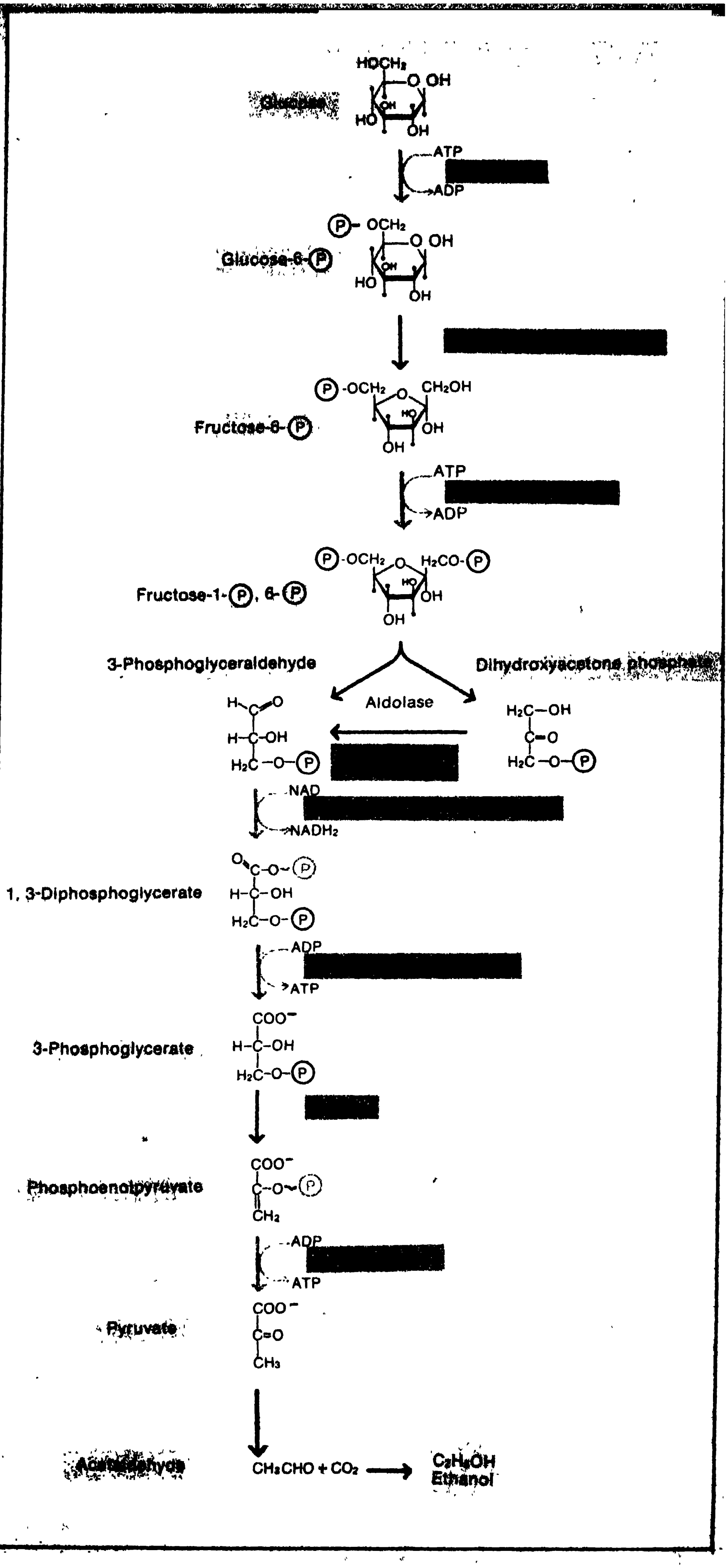
Photosynthesis is one of the most important biological processes on earth. In essence, it is the conversion of light energy by the cell into chemical energy stored in the high energy bonds of adenosine triphosphate (ATP) that can be used for the formulation of cellular constituents from atmospheric carbon dioxide. The ability to photosynthesise depends on the presence of green pigments — the chlorophylls which are found in plants, algae and some bacteria. It has been found that photosynthetic reduction of carbon dioxide consists of two more or less distinct sets of reactions: the light reaction in which light energy is converted into chemical energy, and the dark reaction in which the chemical energy is used to reduce carbon dioxide to organic compounds. This way, plant photosynthesis fixes about 2 x 10 ^{11} tonnes of carbon annually with an energy content of 3 x 10 ^{21} joules; this is about 10 times the world's annual energy use and 200 times our food energy consumption.

Though solar energy is a very attractive source for the future, its direct utilisation has some limitations. The enormous expenditure involved in collection and storage and the seasonal variations are some of the bottlenecks. Therefore, the indirect use of solar energy by converting the biomass into liquid fuel like alcohol is gaining ground. And biomass is a renewable source.

The most spectacular example of the utilisation of biomass is the massive Brazilian project for the production of fuels like alcohol from biological sources. By 1982, Brazil hopes to substitute 20 per cent of its gasoline consumption by alcohol and eventually hopes to save US $ 5 billion in terms of reduced petroleum imports, besides the creation of 135,000 additional jobs. This is one of the few successful ventures [illegible]

Fig.2 Cassava is the most important starchy root or tuber of the tropics and the annual world production is 10^8 tonnes. The leaves are deeply palmately lobed, and the roots are enlarged by deposition of starch and constitute the principal source of food Tuberisation occurs gradually about 10 or 12 months after planting. Once harvested, the roots deteriorate within a few days

Fig.3 (right) Enzymatic reactions in the conversion of glucose to alcohol and carbon dioxide by yeast under anaerobic conditions (Glycolysis or the Embden-Meyerhof pathway)



taken by a developing country to utilise domestic technology for achieving economic stability. Production of additional alcohol will no doubt be one of the future programmes of any developing country as long as the energy crisis exists.

Why cassava alcohol as a fuel?

Production of ethanol for motor fuel has received a new impetus in India also. Most of the current ethanol production in India comes from molasses. About 438 million litres of alcohol could be produced from the 2.06 million tonnes of molasses available for fermentation. (Though the total molasses production is 2.97 million tonnes, some of it is used in the cattlefeed industry.) The bulk of the alcohol produced goes for beverages, chemical industries, pharmaceuticals and laboratories.

The total requirement of gasoline or petrol for automobiles and other internal combustion engines in the country is about 2,117 million litres (source: *Cooperative Sugar*, 1978). If alcohol is blended with petrol at 20 per cent, petrol consumption can be reduced to about 1693.40 million litres. This would need on additional production of about 423.60 million litres of alcohol.

Molasses and cassava are the two

ig.4 A standing cassava crop

najor biomass sources for energy roduction in India. Since sugarcane equires well-irrigated lands and roperly managed agronomic pracices, extension of its cultivation from he present 32 million hectares has ome limitations. Moreover, the land sed for cereal production cannot be onverted to sugarcane. Cassava, eing more tolerant to adverse soil nd climatic conditions, thus emerges s an excellent source of carohydrates for alcohol production.

An additional production of 423.60 nillion litres of alcohol would need .82 million tonnes of raw cassava (at he rate of 150 litres per tonne), which an be obtained from 0.17 million ectares of land (with an average ield of 16.6 tonnes per hectare).

Will diverting cassava to produce ower alcohol affect our food basket? he fear seems to be unfounded. eing a food item next in importance o rice, the demand for cassava as ood is closely related to the price and vailability of rice. If a remunerative rice for cassava is assured, it will tabilise the demand in various secors. The projection made by the ommittee for Implementation of uber Crops Development Scheme in erala during the Sixth Five Year lan throws light on the distribution attern of cassava in Kerala. It is 2.1 nillion tonnes for human conumption, 0.6 million tonnes for ndustrial purposes, 0.6 million onnes for export to other states, 0.05 nillion tonnes for cattlefeed and 0.2 nillion tonnes for diversified products. This makes a total of 3.55 milon tonnes.

Cassava yield can be increased to [illegible] metric tonnes per hectare by cultivating high-yielding varieties like -2304, H-1687 and H-165 and by dopting the package of practices recommended by the Central Tuber Crops Research Institute. If there is a continuous intake of tubers and fewer marketing problems, the required quantity of cassava for power alcohol production will be available throughout the year. Cassava can also be converted to dried chips and stored for later use.

Table 1 gives a comparative account of the contribution of energy by cassava, sugarcane and molasses and the cost of power alcohol production. It can be seen that cassava has a higher percentage of fermentables than sugarcane and the yield of alcohol from it per tonne of raw material is higher. This alone will make the price of power alcohol from cassava more attractive than that from sugarcane. Rapid multiplication of the high-yielding and high starch-containing varieties can lead to a higher alcohol yield per hectare of cassava, further bringing down the [illegible] the price of alcohol from molasses has become attractive only because of the statutory control imposed on the price of molasses.

Fermentation of cassava for ethanol

Production of ethanol from starch is not new in fermentation technology. No attempt has yet been made for recovering alcohol from cassava in India. The Central Tuber Crops Research Institute, Trivandrum, has now developed and standardised the techniques for the fermentation of cassava for alcohol production.

Fresh cassava roots or cassava flour can be used for ethanol production (Fig.5). The first step is gelatinisation and conversion of starch to simpler sugars by a process called saccharification with the help of saccharifying agents like mild acids, amylase enzymes and substances containing amylase enzymes, like malt. The hydrolysis process and the utilisation of an efficient low-cost saccharifying agent are important factors in the production of fuel from starch.

The starch is cooked first to release the starch granules which are bound to the lignocellulosic compounds of the roots. This will also facilitate the reaction between the saccharifying agent (acids, enzymes, etc) and the lower substrate. Cassava starch, having a lower swelling and gelatinisation temperature, can be easily saccharified to simple sugars with the help of acids or enzymes. The main advantage of cassava over any other energy crop is the presence of high fermentable sugars after the saccharification. The use of a dilute acid solution helps to recover about 98.8 per cent reducing sugars from the starch. Higher yields of alcohol have been achieved by hydrolysing cassava starch slurries at 1 atmosphere with 0.1 N hydrochloric acid using a cassava to acid solution ratio of 1 to 3.

Table 1: A comparative study of productivity and cost of alcohol from cassava, sugarcane and molasses

Crop	Crop yield* (t/ha)	Fermentables (%)	Crop cost (per tonne)	Yield of alcohol (l/t)	Alcohol productivity (l/ha)	Cost of power alcohol** (Rs./lit)
Cassava	16.61 (Raw tubers)	30	250.00	150*** (Raw tubers)	2490	1.66
Sugarcane	56	9.6	135.00	48	2688	2.81
Molasses	2.8****	50	60.00†	245	686	0.24

* 8-10 months old rainfed crop
** Based on the price of raw material
*** From varieties containing 30 per cent starch
**** By-product of sugar industry
† Controlled price

reactions which set a limit to the yield of glucose that may be obtained, the formation of high inorganic salts due to pH adjustment, corrosion of the machinery, etc are some of the disadvantages of the use of acids in the saccharification process.

The enzymes amyloglucosidase (glucoamylase or glucamylase) derived commercially from strains of the mould *Aspergillus* and *Rhizopus* can hydrolyse gelatinised starch completely to glucose. It acts by clearing the α-1, 4 glycosidic linkage of the non-reducing terminal glucose unit. It can also hydrolyse α-1, 6 linkages from the amylopectin. Malt contains the three most important enzymes for starch breakdown, namely, α-amylase, β-amylase and α-glucosidase. Alpha-amylase splits the α-1-4 links randomly within the molecules forming dextrins, which are small chains of glucose. This makes the gelatinised starch slurry more fluid and supplies more chain ends for the action of saccharifying enzymes. Since all the α-amylase cannot split the α-1-6 links of starch and dextrins all the branch points remain intact after α-amylase action. The β-amylase also breaks the α-1-4 links of dextrin and starch but only from the non-reducing ends of the molecules, resulting in maltase formation. Since neither of these enzymes attacks the α-1, 6 linkages, their combined action converts only up to 85 per cent of the starch into reducing sugars. The alpha glucosidase splits the α-1, 6 linkages of the maltose and shortchain carbohydrates, thus completing the hydrolysis of starch into fermentable sugars. The continued action of the above enzymes produced from microorganisms can also split the cassava starch to glucose units.

Since amylase enzymes do not tolerate temperatures above 55° C, they must be added after gelatinisation has taken place. The use of heat-stable α-amylase has received considerable attention at least for effective conversion of starch to sugars.

Large volumes of the saccharified starch is fed into fermentation vessels and inoculated with actively growing yeast, *Saccharomyces cerevisiae*. Many strains of yeasts, with varying capabilities and tolerance, have been reported. The yeast inoculation is usually 5 to 10 per cent of the total volume and is grown aerobically in stages, from a laboratory pure culture. The optimum concentration of sugars for ethanol fermentation is 12 to 18 per cent. The pH of the mash for fermentation is optimally 4 to 4.5 and the temperature of the fermentation 28 to 32°C. Alcohol is recovered from the fermented mash after 48 to 72 hours. At the end of fermentation, the yeast is separated from the mash by centrifugation or sedimentation and used for the next batch of fermentation. The resulting liquid is distilled for the recovery of alcohol.

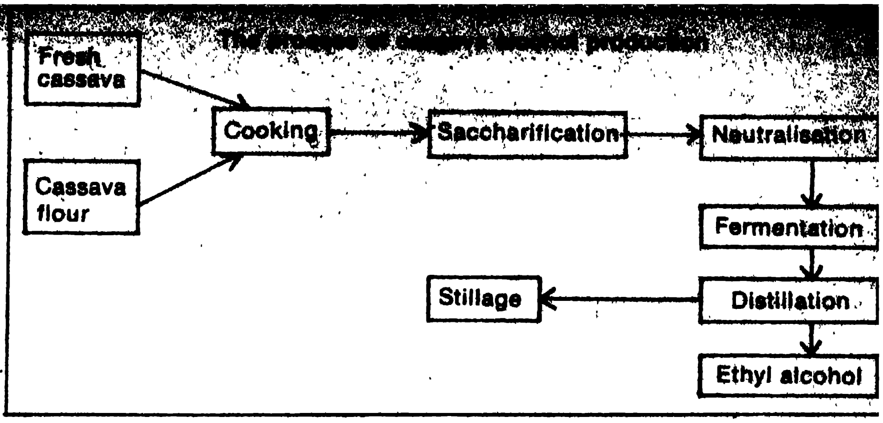


Fig.5

Biochemistry of alcohol fermentation

Even in the absence of an external electron acceptor, many organisms can still oxidise some organic compounds with the release of energy—a process called anaerobic fermentation because it occurs in the absence of oxygen or air. The conversion of simple hexose sugars to ethyl alcohol by yeasts through a well-documented series of enzyme-catalysed reactions was elucidated by the classicial studies of Embden-Mayerhof and Parnas in 1930 (Fig.3).

Under aerobic conditions, glycolysis or Embden-Mayerhof pathway provides pyruvate for entry into the tricarboxylic acid cycle and then by oxidative phosphorylation to carbon dioxide and water, giving maximum quantity of energy per unit of sugar utilised. Under anaerobic conditions or high sugar concentration, yeasts convert the pyruvate to ethyl alcohol and carbon dioxide with the production of energy. The end product needed is the coenzyme, nicotine adenine dinucleotide (NAD) and the ethyl alcohol is an unwanted by-product for the organism. These partial oxidations involve the use of the same substance as both electron donor and electron acceptor which means that some molecules of the compound are oxidised and others are reduced.

The overall reactions involved in the conversion of glucose to ethanol by yeasts in the absence of oxygen can be represented as:

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \longrightarrow \underset{\text{Ethanol}}{2\ CH_3CH_2OH} + \underset{\text{Carbon dioxide}}{2\ CO_2} + \underset{\text{Energy}}{57\ \text{K cal.}}$$

Energy gain or loss

The energy loss and gain in the process of alcohol production is a subjec of debate among the scientists. It i true that the processing of cassav requires steam for the liquefaction an hydrolysis. McCann and Prince 1978, have estimated that approximately 100 kg of steam is require for producing 100 litres of alcoho from cassava. A detailed energ budget was also prepared by the sam authors (Table 2).

Table 2: Cassava energy budget (MJ kg dry cassava tubers

In		Ou	
Cassava tubers	16.2	Alcohol	10.
Cassava tops	8.1	Peelfibres	1.
Farm and transport			
Tubers	1.0		
Tops	0.5		
Electricity (secondary)	0.7		
Other (additives)	0.1		
Total	26.6		12.7

The net energy ratio (NER)

$$= \frac{\text{Energy in power alcohol.}}{\text{Non-crop energy inputs (Farm, distillery, transport, etc)}}$$

$$= \frac{10.8}{2.3} = 4.7$$

It can be seen from the table that the net energy ratio for cassava is 4.7.

Dr. Balagopalan is microbiologist at the Central Tuber Crops Research Institute, Trivandrum, currently working on the fermentation of cassava starch for the production of industrially important products. He is also working on the plant-microbe interrelationship in cassava.

Dr. Hrishi is Director of the Central Tuber Crops Research Institute.

The playful dolphin

B. F. Chhapgar

The dolphin is said to be very intelligent. Man aims to set up a conversation with this graceful animal

Dolphins evolved some 50 million years ago from land animals that may have resembled cattle, pigs and buffaloes. They lost their fur when they took to water and developed instead a thick coat of blubber They became sleek and streamlined and evolved modifications suited to aquatic life They are social animals

THE SCIENTIST lowered objects of various shapes and sizes into the water alongside the floating dolphin pen. He was playing a game of Twenty Questions. His partner in the pen was a female bottlenosed dolphin named Kae. As he sounded an underwater tone which was equivalent to asking "Is anything out there?", the lady let off a series of staccato clicks. These are echolocation sounds dolphins make to find their way about. Kae responded to the question by nudging a red ball. It signified "yes" in the pre-arranged code.

His next question was: "Is it cylindrical?" He lowered cylinders of various materials, proportions and sizes into the water. And every time Kae replied with a "Yes". He then dropped an angular iron rod into the water. Kae promptly nudged a blue ball. It meant, "No". By means of such "yes-no" responses, a lot has been found out about what the dolphin perceives with its sonar. A dolphin's sonar is said to be about ten times as sensitive as any man-made echolocation equipment.

But sonar is only one of the many fascinating things about dolphins—the air-breathing aquatic mammals which have for long beguiled oceanarium audiences with their cleverness and sportive capers. The other things scientists aim to find out are whether dolphins have a language, and whether it is possible for humans to set up a two-way communication with them. Dolphins, after all, have exceptionally large brains, are quick at learning tricks and have a better auditory memory than man. Since they live in groups, they must have some kind of a social structure. But do they also have a culture?

Dolphins belong to the same order of mammals (Cetacea) as whales, but are classified in a separate sub-order, Odontoceti. They are believed to have evolved from land mammals some 50 million years ago. They are on an average about 2.4 metres long and unlike whales, they have a single blowhole. Their peg-like teeth are uniformly set in the jaws and they can hold their prey cleanly. The jaws generally end in a 15 cm beak. The terms 'dolphin' and 'porpoise' are used interchangeably, but the term 'porpoise' is sometimes used for the species that lacks a beak and has spade-shaped teeth. The largest dolphin species is the 7.5m killer whale *(Orcinus orca)*.

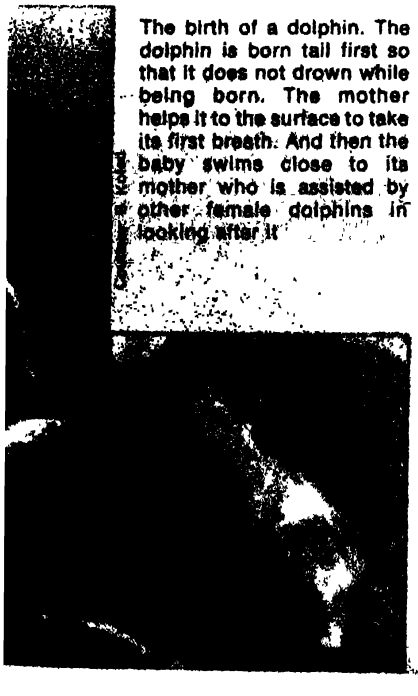
Most of the information about dol-

phins comes from studies of captive animals, because marine creatures are still difficult to study in the wild. Man started keeping cetaceans since the early 1940s when the world's first oceanarium came into being at St. Augustine, Florida, USA. Because of its easy availability (in USA), and amenability to captive life, the commonest dolphin kept in oceanariums is the bottlenosed Atlantic dolphin, *Tursiops truncatus*. Unfortunately, the common porpoise *(Phocaena* sp.) is hard to keep in captivity. It is a delicate creature that readily goes into a state of shock. Yet Professor R-G. Busnel of Denmark has maintained a few of them successfully in his laboratory.

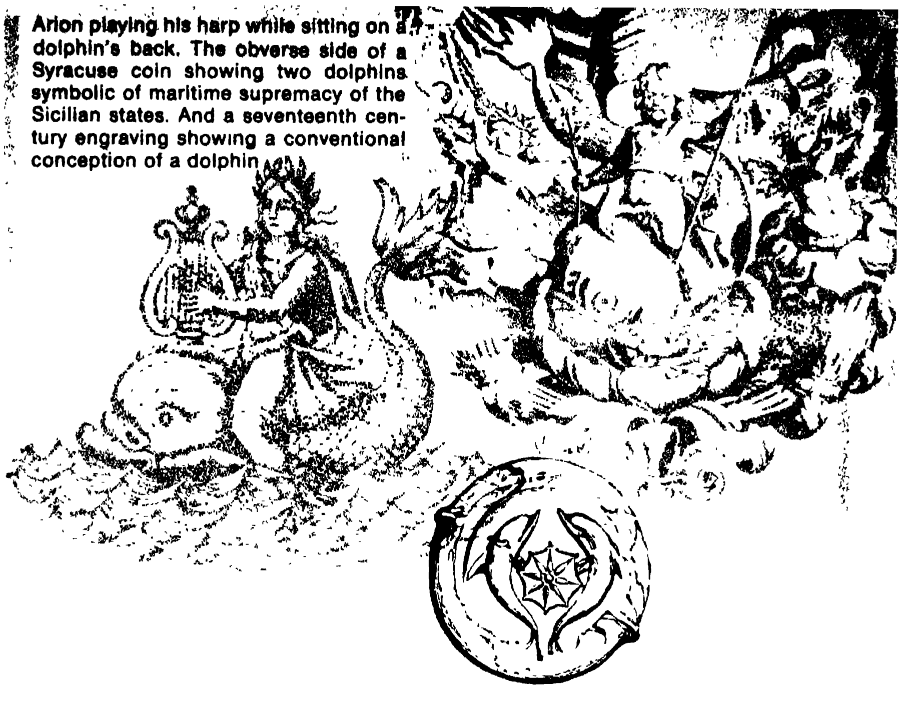
Catching dolphins is a delicate operation. After surrounding them by nets, they are gently transferred to 'beds' padded with foam plastic, and sponged with cool seawater to prevent their skin from drying. They lie quietly without struggling, as if they know their captors would do them no harm. Even killer whales, reputed for their fierce rapacity, have been kept in captivity and found to be extremely docile. They even allow their trainer to ride on their back.

But captive dolphins are susceptible to erysipela blood-poisoning (a disease akin to hog-fever). Their commonest trouble arises, however, out of their innate curiosity. Just as with monkeys in the zoo, they are readily attracted by objects dropped into their tanks. They taste and sometimes swallow them with disastrous effects.

Being mammals, dolphins give birth to live young and suckle them. Interestingly, the new-born calf escapes drowning by coming out of the mother's womb, tail first, and immediately rising to the surface to



The birth of a dolphin. The dolphin is born tail first so that it does not drown while being born. The mother helps it to the surface to take its first breath. And then the baby swims close to its mother who is assisted by other female dolphins in looking after it



Arion playing his harp while sitting on a dolphin's back. The obverse side of a Syracuse coin showing two dolphins symbolic of maritime supremacy of the Sicilian states. And a seventeenth century engraving showing a conventional conception of a dolphin

A friend at sea

PROBABLY no other marine animal has been so much linked with man in legend and lore. Sailors from the days of Aristotle and Pliny have keenly observed dolphins and their habits, and numerous tales, some factual and some half-truths, have gradually been woven around these animals. There are the legends of dolphins being attracted to music, carrying children piggy-back, or driving away sharks from shipwrecked sailors.

Infuriated dolphins (and whales), it has been believed, are lulled by music. Pliny the elder has more than one legend to recount of dolphins. The musician Arion, when about to be thrown into the sea by robbers, implored them to be allowed to play a last tune on his harp. Hearing him play, a dolphin came and took him on its back off to safety.

Then there is the legend of dolphins carrying people on their back. During the reign of Augustus Caesar, a young boy staying at Baianum and going to school at Puteoli used to shout "Simo, Simo" repeatedly, when a dolphin would come and take him on its back.

Pliny also writes of the fishermen from southern France as well as from the coasts of Mauritania near Cape Blanco, calling dolphins by shouting "Simo, Simo" whenever they wanted to herd mullet into their fishing nets.

Egesimus tells of a boy named Hermias in the city of Iassus, who daily rode a dolphin. One day they were caught in a violent storm and the boy died, whereupon the dolphin, realising that it was the cause of his death, jumped out of the sea on to dry land and also died.

American Indians in Brazil and Peru consider the river dolphin (called *bouto* in their native dialect) sacred. The male dolphins are supposed to be very fond of pretty young girls. They disguise themselves and attend dances during carnival time. When an unmarried girl gets pregnant, the people believe that a dolphin is responsible. The father of the child is dutifully recorded in the birth certificate as "Bouto"!

Although one may be inclined to pooh-pooh legendary stories, there appears to be some truth in them.

In New Zealand, a dolphin inhabiting Pelorus Sound escorted every ship plying between Nelson and Wellington for its protection, but it disappeared in 1912. Presumably, it was killed by whalers. In 1935, a dolphin at Oponini beach (New Zealand) used to play with bathers, allow them to pet and stroke it, and allowed children to ride on its back. The government passed a law to protect it, but it was found dead in March 1956.

There is a newspaper report of a man saved from drowning in the Gulf of Suez by dolphins which protected him from sharks and carried him on their backs. In an oceanarium in Australia, one of the acts in the dolphin show is the simulated rescue by a trained dolphin of a drowning man.

Sir Arthur Grimble reports that when the people of Gilbert Islands need dolphins for food, their headman calls them to the beach at a particular time. And the dolphins come in large numbers at the time he says they will!

B.F.C.

breathe. Another adaptation to aquatic life is in the mode of suckling. The mammary glands do not protrude out of the body, but are recessed into grooves. The mother just squirts the milk into the calf's throat by powerful muscular contractions so that the calf can drink enough milk between visits to the surface to breathe. As among elephants, the other female dolphins in the school take a lot of interest in the baby, solicitously guarding it from predators and even suckling it if necessary.

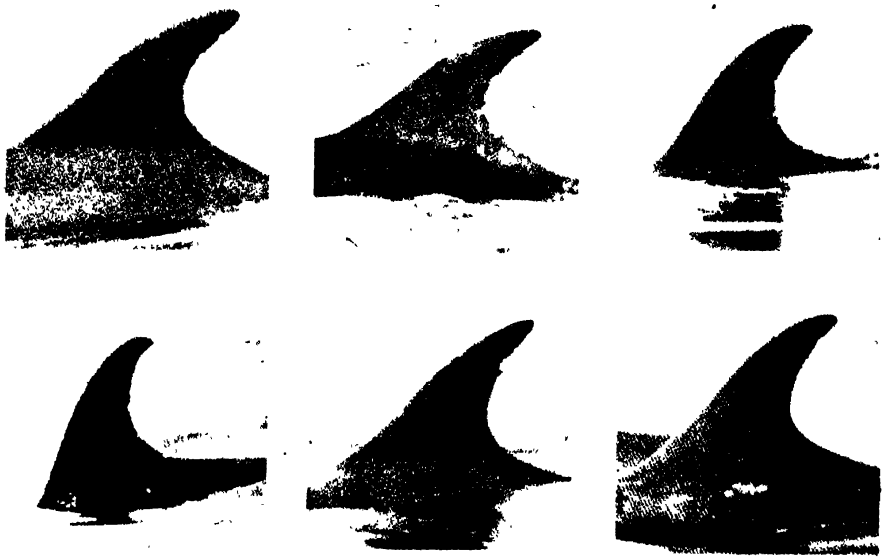
Dolphins are gregarious animals. As many as 20 to 30 small groups can be found in a circle of 10 to 15 km diameter. These groups numbering some 400 individuals may form the mating population. Little, however, is known about their social organisation in nature. Since males and females are found in about equal numbers in groups, there is apparently no harem system, but, as in apes, there are dominance hierarchies. Individuals may migrate from one group to another; the groups are small when food is scarce and larger when it is more plentiful.

Like other mammals, dolphins are warm blooded. But unlike whales, they are also found in tropical seas where the water can be quite warm. Besides, vigorous exercise can also give rise to excess body heat. How do they get rid of this excess heat? They do not sweat or pant like land animals and so are unable to dissipate heat in the form of water vapour from their skin and lungs. But like the whales (SCIENCE TODAY, December 1978), they use a principle commonly known as counter-current heat exchanger. Called the *rete mirabele*, meaning "wonderful net", it consists of masses of small, parallel contiguous arteries and veins arranged alternately and dividing into a large number of intricately twisted branches forming a network of communicating tubes. The warm blood in the arteries is cooled by the blood in the veins running alongside them.

Intelligence

That dolphins are intelligent beings is obvious to anyone who has observed them perform in oceanariums. It is a little difficult though to define intelligence. We may say it is the capacity of an individual for adaptive behaviour. An intelligent being can learn, by insight or imitation, or by trial and error, how to react to a new situation. The size of an animal's brain as well as the ratio of the brain weight to body weight are also related to intelligence. A dolphin's brain has on an average a weight of 1700 grams compared to the man's 1450 grams, and its cerebral cortex is almost as convoluted. The cerebellum, which controls involuntary movement, is also proportionately larger in the dolphin than in man. But the ratio of brain weight to body weight is higher in man. The human brain has a higher neuron density, but has fewer axon-dendritic interconnections than the dolphin's brain.

The size and complexity of the dolphin's brain, its learning ability and its gregarious nature have encouraged scientists to gauge its potential intelligence. Scientists are trying to assess a dolphin's intelligence by giving it problems to solve. In designing such experiments, care is taken to see that the problem suits the animal's physiological requirements; their physical and sensory limitations are also taken into consideration. For example, dolphins dislike swimming through narrow openings, they are afraid of black and white colours (Dolphins kept at the Marineland of the Pacific, an oceanarium in California, demonstrated this by splashing water over black-clothed Catholic priests). Unlike other animals but like chimpanzees, dolphins do not always respond to the rewards of food offered to them for having solved a problem; therefore, the problem should be such that it motivates them to solve it or treat it as a game. In this way, the dolphin may learn up to five or more tricks at a time. However, if a problem is too tough, it upsets the animal. A dolphin trained by Dr. Winthrop Kellogg and Charles Rice, faced with a difficult problem, got so frustrated that it picked up a plastic pipe in its mouth and battered the test equipment with it, literally throwing a tantrum. Occasionally cetaceans turn aggressive under extreme neurosis ("The Mourning Whale", SCIENCE



All dolphins of a species look alike How does one recognise a dolphin? Scientists look for pattern of nicks and scars along the trailing edge of its dorsal fin. Shown above are the dorsal fins of some bottlenose dolphins of a group of 50. All dolphins in the group were identifiable

A question of speed

ONE PUZZLE about the dolphin is its speed. A 2.5-metre dolphin should theoretically have a top speed of 19.5 kmph. However, dolphins are known to swim effortlessly at double this speed for as long as half an hour A 1.8-metre dolphin weighing 135 kg would have to develop 10.5 kW (14 hp) to swim at 45 kmph, that is, more than seven times the power that an athlete's muscles can produce. And the dolphin does not have such efficient muscles. How then does it swim so fast?

By measuring the length, weight, surface area and muscle power of a swimming animal, and the drag coefficient (measured by towing a model through water), and using mathematical formulae based on the laws of hydrodynamics, the top speed of the animal can be predicted.

A 27-metre blue whale, weighing 122 tonnes, can maintain a sustained speed of 26 kilometres per hour (kmph) for two hours, and can increase its speed to 37 kmph for brief spurts of ten to fifteen minutes. The muscles of the whale constitute 40 per cent of its total body weight, and since its tail flukes are large and move slowly up and down, the loss of power in kinetic energy in the water displaced will be much less than in a case where a smaller volume of water is *displaced at greater speed, for example, a boat's propeller. The whale would need to develop 185 kilowatts per tonne at cruising speed and double this output at top speed. The calculated power output for the whale comes to 6.8 kW per tonne, while the figure for actual output of the whale at top speed is 3 kW/tonne which indicates that a whale's muscles are not unduly taxed by the affort.*

Obviously these animals have reduced their muscular effort in locomotion by reducing the frictional resistance offered by their bodies to water.

When a streamlined object is towed in water at a slow speed, the water flows around it smoothly; this is called laminar flow. As the towing speed is increased, a critical stage is reached when the water flow breaks up into eddies, termed turbulent flow, which resist forward motion. The outermost layer of the dolphin's skin is very soft and has numerous vertical ducts filled by a spongy water-logged material. The texture of the skin, together with the formation of temporary ripples in the skin during fast swimming, minimise the turbulent flow and reduce the drag.

This information has been put to practical use in designing air and water craft. A flexible rubber coat on the hull of a high-powered speedboat has helped reduce drag by 27 per cent, allowing an eight per cent speed increase. Carefully designed slots and apertures in an aircraft's wings can eliminate boundary layer drag.

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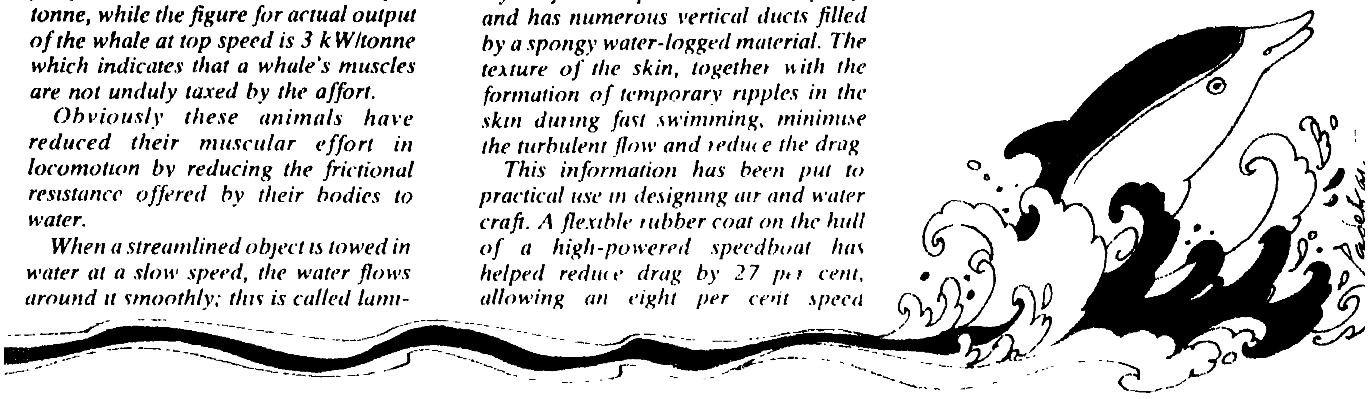


TODAY, December 1978).

Like all animals, dolphins are trained by "conditioning", a reward being given for correct response to the trainer's cue. They can even teach themselves tricks without being guided by a human trainer. To cite an example, D. Brown, and D.K. and M.C. Caldwell had kept together a spinner dolphin *(Stenella roseiventris)* with a bottlenose dolphin at the Marineland of the Pacific. The spinner has a natural habit of jumping out of the water and rotating corkscrew-wise before diving back. The bottlenose, on the other hand, leaps out and dives back without spinning. When this pet spinner spun in response to the trainer's cue, the bottlenose also imitated it and spun, although its spin was not a very polished one. Brown and Caldwells had also kept a False killer whale *(Pseudorca crassidens)* with some trained dolphins. As the dolphins performed their acrobatic tricks, the killer whale watched them and soon picked up the tricks, performing them adroitly even though it had never been trained.

Dolphins are a byword for playfulness and have a built-in *joie-de-vivre*. They play tag with other dolphins for up to half an hour without tiring and will also play with rubber balls or motorcar tyre tubes. They throw the tubes out of their pool for men to catch and return. They frequently tease other animals: coming up behind a sleeping penguin, they will pull its feathers, or lure a fish out of its hiding place by offering a morsel of food, and then gulping the food when the fish comes out to eat it. One dolphin, which wanted to make an eel come out of its hole, killed a turkey fish, broke one of its spines and used that to poke the eel out of its hiding place.

We do not know how acute the dolphin's eyesight in air is. But obviously, underwater, the animal depends greatly on its remarkable sonar system which helps it to see as well as to sense the shape and composition of objects around it. On the exact mode of sound production, there is little agreement. However, it is believed that a dolphin produces a variety of sounds by shifting air between nasal sacs inside the skull, below the blowhole. The latter is a highly complex organ equipped with airsacs, tongue and lips and all the complicated muscles which in land animals control facial expression. By means of its blowhole a dolphin can simultaneously produce two types of sound, somewhat like a man whistling and whispering at the same time. One type of sound, which is variously described as barks, bleats, clicks, mews, squawks, squeals, wails, whistles and yelps, is made both above and below the water and appears to be the result of such socioemotional interactions as fear, play, protest, threat and sexual arousal. For example, a single, rising and falling bird-like cry is made by a juvenile dolphin when calling its mother. It is this vast range of pure tone whistle emissions that makes scientists speculate that dolphins have a definite language.

Sonar

The second kind of sound dolphins make is the pulsed ultrasonic series of clicks. Often called "rusty hinge" sounds, it has been recognised only for the last three decades or so. Scientists are unanimous that, as in bats,

Left . A baby dolphin being suckled by the mother Dolphin mothers have strong pumping muscles to force milk into their offspring

Right : Bouto feigns death

these sound emissions are used for echolocation. These clicks may be focussed by passing them through fatty tissues in the forehead. When the clicks strike an object, they are reflected back and transmitted to the dolphin's brain through its jaw and throat; the dolphin does not hear through its pinholed size ear openings. It is thus able to compute the object's distance, shape, speed, size and direction.

The clicks made by the dolphin are as brief as three-ten-thousandths of a second but are produced in a long series of several hundreds per second. When the clicks impinge on an object, the latter starts to vibrate. The dolphin then hears (1) echoes which are sharp replicas of the emitted sound, and (2) the 'ringing' echo from a vibrating target, which enables the dolphin to gauge the material of which the object is made and its size. Thus, from the type of the echo, it can differentiate rocks, flesh, and the resonating air bladders of fish. From the time-interval between a click and its echo, the dolphin can gauge its distance from the object, and the time-difference between many such clicks and their respective echoes enables it to find out how fast it is approaching its target.

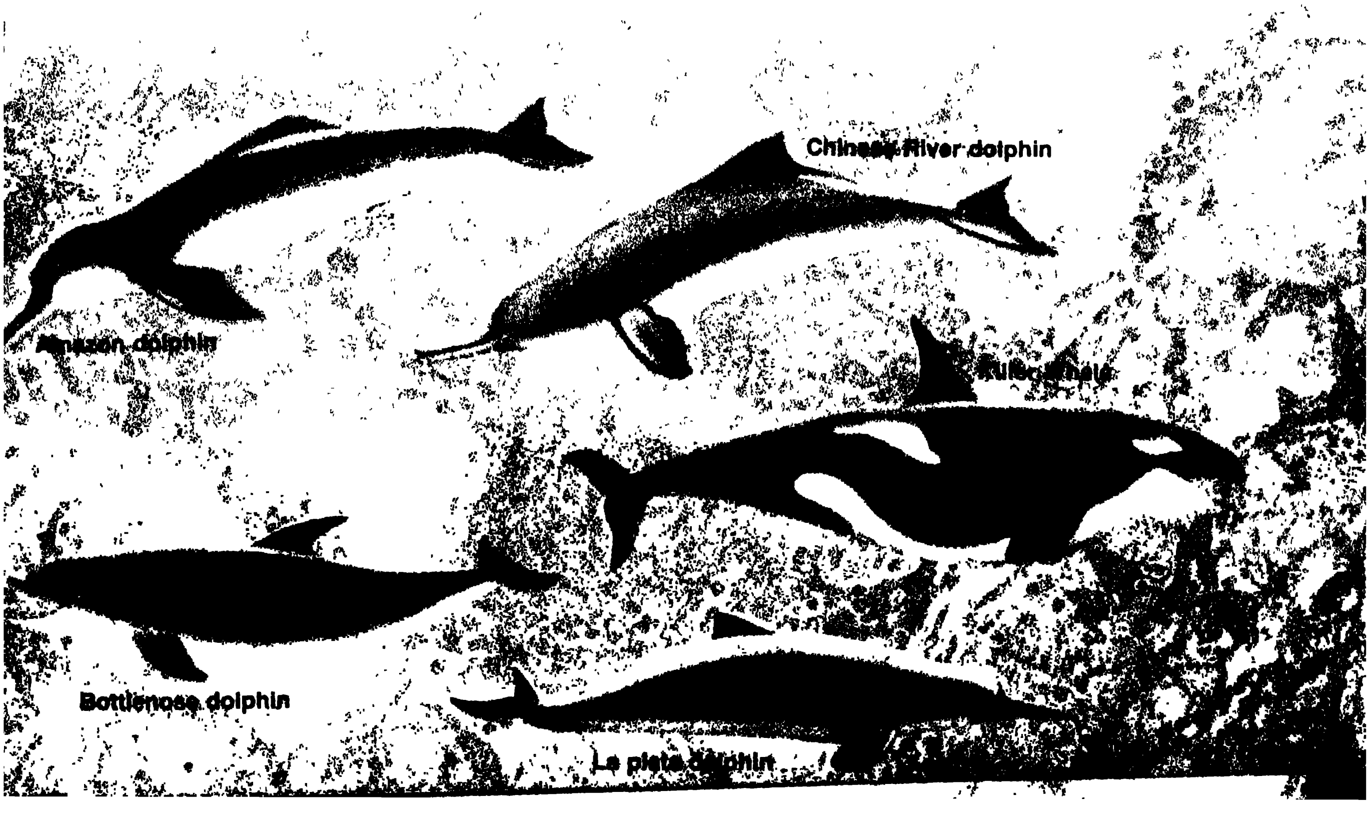
Scientists are not sure whether a dolphin can distinguish a single click among a train of several hundreds. Probably the principle of 'difference tone' is used. When we drive a car with new tyres along an asphalted road at low speed, we hear individual clicks made by each ridge of the tyre as it strikes the road surface. As the car goes faster, we hear only a hum caused by the merging of the clicks; the hum rises in pitch as the car increases its speed. A similar rise in pitch of the difference tone in a dolphin's clicks may enable it to determine how fast it is homing in on its target.

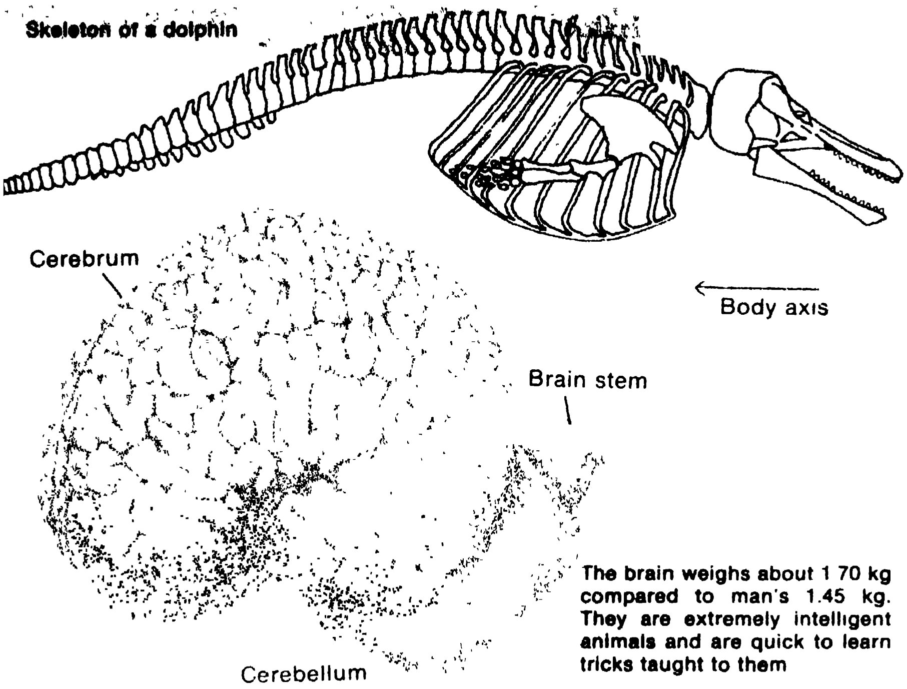
A historic account of the discovery of the use of sonar and echolocation in dolphins is interesting. During World War II, when the importance of sonar for detection of submarines was realised, men lowered listening devices into the sea. What they found was not the 'silent world' of Jacques Cousteau, but a veritable cacophony of sounds which were ultimately traced to fishes, pistol shrimps, dolphins and whales.

About this time, Arthur McBride, curator of the world's first oceanarium at Florida, USA, while trying to catch bottlenose dolphins alive, observed that they would swim headlong down a channel to the sea, but would abruptly stop short 30 metres from a net strung in their path. When he made the meshes of the net larger, however, the dolphins could be trapped. McBride surmised that the dolphins used sonar as an echolocation device just as bats do. William Schevil and Barbara Lawrence taped dolphin sounds at Marine Studios and found that they were high frequency sound emissions exceeding 100 kilocycles per second (the human ear cannot hear sounds of over 20 kcps frequency). They then used a trained dolphin in a simple test: it had to choose on which side of a long net to swim to get its reward of a fish held at the other end. The test was conducted in murky water and far beyond the limits of its vision. It invariably chose the correct side, all the while emitting the sharp clicks.

Meanwhile, Winthrop Kellogg, also at Florida, used a barrier bisecting a pool, with two transparent perspex sheets as gates. Only one of the gates was opened at a time and the dolphin had to go through it in the murky water; it invariably chose the open gate and never crashed into the closed one. When Kellogg dropped objects as small as a BB lead shot into the dolphin's pool, the dolphins on hearing the tiny splash accurately reached the object. But if a spoonful of water was thrown, they ignored it and they would swim on unconcerned.

R-G. Busnel at Paris found that dolphins could negotiate mazes with obstacles of iron wires strung along the path without bumping into them, but bumped into nylon wires (nylon is acoustically 'transparent' to dolphins). John Prescot and Kenneth Norris blindfolded a dolphin and found that even then it could unerringly find its way along a maze. From nine metres away it could home in on a target like a small disc. They can even tell the differences in size. Ronald Turner and K. Norris trained a dolphin to distinguish between two ball-bearings of dissimilar sizes. It





The brain weighs about 1 70 kg compared to man's 1.45 kg. They are extremely intelligent animals and are quick to learn tricks taught to them

could easily detect the difference between ball-bearings of 51 and 63 millimetres diameter. With ball-bearings of 57 and 63 mm diameter, it could detect the larger one with 70 per cent accuracy. When confronted with two ball-bearings both of 63 mm diameter, the dolphin would show that it was being fooled by turning away and refusing to test them! William Evans trained a dolphin to differentiate between two different metal plates of the same size and thickness. It could detect them blindfolded since different metals produce different types of echoes. But when presented with one metal plate thicker than the other, so that both were acoustically identical, the dolphin was puzzled.

Dolphin language?

We now come back to the question: do dolphins have a language. As we humans understand it, language is the ability to convey one's thoughts by the use of arbitrary symbols (such as 'words' in human languages or signals like the wagging of a dog's tail) in proper syntax. These symbols or signals can be utilised by an individual to build up in his mind a picture of the outside world, in which he can test his responses before committing an action. He can also use the symbols and signals to convey the images in his mind to other members of his species. Thus, language is a two-way tool for thought transmission.

Dolphins are, in theory, excellent subjects for studying communication. They are co-operative, intelligent and, most of all, because their communication is conducted by sound, the most convenient mode for a quantitative study is through recordings on a magnetic tape. In fact, two dolphins, isolated and immobilised in separate pools, but linked by a telephone, will exchange a variety of sounds as long as they can hear each other, which strongly confirms the suspicion that dolphins can talk. But the more scientists study dolphin communication, the more perplexed they get, being faced with an apparently complex, codified 'language', if it is really a language.

More exciting than dolphins' communication among themselves is the prospect of a dialogue between dol-

Fresh water dolphins

In the Tertiary period, when the seas receded, several genera of marine dolphins got trapped behind in rivers. They adapted themselves to life in fresh water. Belonging to the family Platanistidae, these dolphins belong to four genera. All are distinguished from their marine cousins by the long, forceps-like snout and a low, rudimentary dorsal fin. The best known is the *bouto*, or Amazon dolphin *(Inia geoffrensis)*, found in the Amazon and Orinoco river systems. Tonina, or the Franciscana dolphin *(Pontoporia blainvillei)*, is the smallest fresh water dolphin; it lives in the Rio de la Plata. It grows only to one and a half metres Tonina is the only platanistid which has a symmetrical skull.

Then there is the Chinese, or white-flag dolphin *(Lipotes vexillifer)*, which grows to 2.4 metres. It is found in the Tungt'ing Hu Lake, 960 kilometres from the headwaters of the Yangtze Kiang. Lastly, we have our own *susu* or Gangetic dolphin *(Platanista gangetica)*, of the Ganga and Brahmaputra rivers as well as the Karnaphuli river in Bangladesh and the Indus in Pakistan. Some taxonomists consider the Indus dolphin as a separate species, calling it *Platanista indi*.

Dr. Giorgio Pilleri of the Institute of Brain Anatomy, University of Berne, has studied the Gangetic (Indus?) dolphin, both in its natural habitat in Pakistan as well as in captivity in Switzerland The susu is blind, and its eyes do not have even lenses. During daytime it stays in the deeper parts in the turbid, almost opaque, river waters, but at night it comes into shallow water only 30 centimetres deep to hunt demersal fish and prawns. It habitually swims with the body inclined to one side, generally the right, with half the tail and one flipper out of the water. It can hear sounds having a frequency of 100,000 Hertz.

Although generally considered taboo, the susu is hunted for food and for medicinal purposes. The oil from the blubber is used for massaging aching muscles, as a tonic syrup for general debility, and as feed for sick livestock The *susu* is in dire danger of extinction.

Unlike the sleek and handsome marine dolphins which are admired for their beauty and intelligence, the fresh water dolphins border on ugliness They are beady eyed, humpbacked, long snouted and have a loose skinned appearance. The bouto in addition has a grapefruit-sized lump on the top of its head. It is very lethargic. Its habit of curling up and going to sleep on its back on the tank bottom often fools its keepers into believing it to be dead. The natives superstitiously believe that the boutos are impossible to keep in captivity, as they would grow legs and walk away, or sprout wings and fly away! When the University of Florida expedition collected its first boutos in Colombia, the local military commandant stationed sentries around their holding pen to prevent their escape by these methods. They also believe that the dolphins disguise themselves as men to attract pretty girls (see box on p 33) Bouto's eyes are valued by the American Indians as love charms.

Boutos remain submerged for two minutes, after which they surface, about 30 metres from where they had last submerged, to breathe. When about to be caught, they squeal and snap their jaws, but then remain calm for an hour and a half. After this they start squirming; they can turn back on themselves vertically or horizontally even in a confined space. They can also move their heads and tails at right angles to the body. When an individual is caught other members of its herd remain around the captive until it is placed in a boat, and sometimes even follow the boat. This habit is well known to whalers, who know that a wounded or captured whale will attract its brethren, the habit, termed by the whalers as 'standing by', is often exploited to trap and kill more whales.

Boutos have been kept in captivity since 1966. The first young bouto to be born in captivity was at the Fort Worth Zoo in Texas in 1968, but it died soon after.

Unlike the susu, the boutos appear to have fair vision They often raise their heads out of water and approach the keeper when he brings fish to them. Their bulging cheeks prevent them from seeing food lying on the tank bottom, so they turn upside down to pick up bits of fish. Their optic nerves are also well developed.

Like other dolphins, their echolocation system is well developed. Like the *beluga* (white whale) of the Arctic, boutos often inflate the large sacs in their heads with air; this plays some part in sound production.

They like tactile stimulation, especially the females and the young. They swim with their flippers touching or their bodies rubbing each other. Young boutos seek out a larger animal and constantly swim under it, with some part of their [illegible] usually in contact Newly born boutos nurse once every half an hour or so, [illegible] almost from the moment of birth emit the clicking sounds used for echolocation.

phin and man. Quite a few experiments are going on on these lines. Thus Margaret Howe tried for two and a half months to teach a dolphin to speak English. At the end of this period it had learnt to shape its sounds to her words, first in spacing and then in structure. Dr. John Cunningham Lilly, the pioneer in dolphin studies, finds that a dolphin will learn to repeat, almost faultlessly, the exact number of sounds that he makes, and ultimately 'speak' the sounds themselves. Unfortunately its utterances are difficult to hear, for apart from being ultrasonic it speeds up and compresses its sounds.

Based on the experiments conducted with chimpanzees by Dr. David Pennack of the University of Pennsylvania is the Porpoise Language Acquisition Project carried out at the oceanarium at St. Augustine, Florida. Here William Langbauer is training a dolphin to match a symbol on a steel rectangle with an identical one on a magnetic board. The dolphin is not supposed to 'talk' by vocalisation, but to communicate by using the snout to manouvre the matching sign on the board. The symbols represent words which the animal has to identify and actions which it has to perform; these will, it is hoped, ultimately be used as a means of communication.

On similar lines is the work of Dennis Kastner, in the Project JANUS (Joint Analog Numerical Understanding System) at the Human Dolphin Foundation. He punches abstruse questions on a computer. This experiment is designed to enable dolphins to exchange with humans sounds adjusted more precisely to their hearing range. It is aimed to teach a dolphin a code of 64 sounds after acquiring which, it will, hopefully, be able to 'communicate' with man.

A dolphin trained by Louis M. Herman, professor of psychology at the University of Hawaii, had learnt a 12-word sonic language, comprising simple sentences, such as "Touch the ring", "Fetch the ball". Professor Herman was aiming to extend its vocabulary to 50 or more words, but his experiment was cut short when his two attendants, sore at the harsh, unnatural treatment meted out to his two dolphins, released them in the sea.

Dr. Chhapgar is Scientific Officer for Aquatic Radioactivity Studies at the Bhabha Atomic Research Centre, Trombay. He has recently been elected life member of the International Oceanography Foundation, Miami, Florida, USA.

Random collection on Himalayas

Tectonic Geology of the Himalaya. Edited by P.S. Saklani, Today and Tomorrow Publishers, New Delhi, 1978, 311 pp, Rs 195

IN SPITE of the title and the editor's promise of brain-storming research findings on the Himalayas, what he actually provides is a random collection, possibly from the Himalayan geology seminar held at New Delhi in 1976.

Published literature reveals two main schools of thought on Himalayan evolution. The first is based on the translational recumbent folds or thrust sheet nappes of crustal material and sediment cover squeezed between drifting continents or crustal plates. The second is on vertical tectonics. It used to be fashionable to end up with nappes (of any type), but the 'in' thing in India today is plate tectonics, particularly after Dewey and Bird's 1970 paper linking the Himalayas with the spreading of the Indian Ocean.

All the papers on Himalayan evolution in this volume seem biased in favour of nappes, with or without plate movement. There is none voicing the vertical tectonics. How the editor excluded several other important scientists in the field from his selection is mysterious.

Far from being an isolated range, the Himalaya is only the southern front of the entire turmoil of mountain belts linked into the knotted blister of Central Asia. This is true in spite of all the recent talk of the northward drift of the Indian plate and its subduction under the Asian plate (they both seem to have fortuitously closely-fitting "made for each other" shapes) and their collision squeezing out the Himalaya.

But how was the whole blister produced?

Satellite imagery may be the new tectonic tool, but the field geologists plodding thousands of weary kilometers over the years did not apparently see what the image watchers saw in the blips over the same area, and *vice versa*. The result is that B.N. Raina's conclusions, in his "Review of the Stratigraphy and Structure of Lesser Himalaya of Uttar Pradesh and Himachal Pradesh", from these images have now to be verified by fresh field work to ascertain if they fit in with ground realities, because, as he says, stratigraphy is dynamic and keeps changing. We seem to have made them further fragile by tending to ignore the existing massive ground data.

One can easily discern in this collection the Achilles heel of the nappist concept. The Siwaliks are shown to extend tens of kilometres deep inside the Himalayas under the pile of nappes which are themselves the source of the Siwaliks. The nappes also carry caps of Eocene rocks which underlie the Siwaliks.

Let us examine some of the other papers in the selection:

Ephemeral ideas and nomenclature mark K.S. Valdiya's new stance on his so-called Vaikrita. These are not shown in his sections which possibly do not belong to his paper, "Outline of the Structure of Kumaun Himalaya". He says nothing about the significance of the 1,200 to 1,800-million-year-old igneous intrusions.

There is a vital link missing between S.V. Srikantia and O.N. Bhargava's account of the remote "Indus Tectonic Belt of Ladakh Himalaya: Its Geology, Significance and Evolution" and S.K. Shah's "Facies Pattern of Kashmir within the Tectonic Framework of Himalaya", which could have shed some light on the Indus paleogeography.

A Himalayan glacial valley

B.N. Raina *(op cit)* could have been generous and specified which of his interpretations in the Himachal and UP Himalaya are based on ERTS imagery. To be sure he is appalled by the "bizarre" fossil truths unearthed from unlikely formations. Why else should V.J. Gupta and N.S. Virdi in their paper make a futile plea to let the fossils speak for themselves? Facts continue to be stranger than fiction.

S.M. Remy's "New Results on Lithostratigraphy and Structure of West Nepal Himalaya" bring in non-existent transcurrent faults (except for the known Dangarjong fault in Thak Khola) only to aggravate the terminological and stratigraphical chaos. The gigantic antecedent drainage knives originating in Tibet and incising through the rising Himalayas are forgotten in J. Jaros and J. Kalvoda's paper on "Quaternary Relief Thrusts in the Himalaya, East Nepal".

D. Krummenacher *et al*'s absolute age data in their study on "Petrology, Metomorphism and K/Ar Age Determinations in Eastern Nepal" do not help since sampling was unsystematic, random and partly from morainic debris. Some detrital mica in the Siwaliks could also be as old as that in Newakot sandstone, but what of it?

Either B.S. Jengpangi ("Stratigraphy and Structure of Bhutan Himalaya") or S.K. Acharya ("Stratigraphy and Tectonic Features of the Eastern Himalaya") is holding the Diuri Boulder Slate-Rangit Pebble Slate entity upside down. What is needed is an objective understanding of stratigraphic and structural facts in the regional framework without mixing observations and inferences like Acharya's co-folding of the Main Boundary Thrust and other unseen highly ductile thrusts. Lead-zinc mineralisation need not signify a Thai-Burma homeland for East Himalayan nappes as Acharya thinks because the corollary cannot extend to Nepalese occurrences.

V.K. Verma and R. Kumar ("Role of Tectonics in the Evolution of the Drainage System of the Kud Area, Kashmir Himalaya") are oblivious of the evolution of the Chenab and Tawi valleys across the Murres and Panjal thrusts in their analysis of structural and lithologic control on microdrainage and springs. And A. Berthelsen's "Himalayan and Sveco-Norwegian Tectonics—A Comparison" is rather out of place.

To force a similarity between Alpine and Himalayan tectonics in his "Counterparts in Himalayan and Alpine Anatomy", Biq Chingchang launches off the weak assumption that the Indus sediments are nappes scraped off the oceanic crust during exhaustive subduction. His suggestion of the Ganga trough as an intra-plate subduction zone merits a second glance.

We have only the title of M.N. Saxena's "The Himalaya—A Modified Arc System and the Gravity Tectonics" in the Contents page, but the paper is missing from the text!

The production of the volume is extremely poor. There are innumerable printing errors. Legends are annoyingly haphazard, incomplete and inaccura[illegible] And one final question: does a minis[illegible] Preface ensure quiet acceptance [illegible] discerning geologist?

B.B. NADGIR

Mr. Nadgir, who has spent 13 [illegible] systematic geological map[illegible] the Himalayas in Nepal, is now in c[illegible] coal exploration projects of the Mi[illegible] Exploration Projects Ltd.

The coloured cubes problem

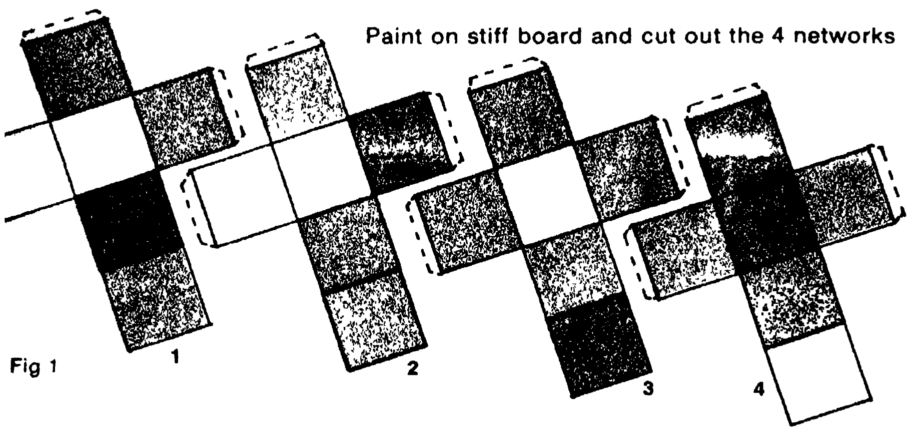


Fig 1

Last month we had seen how graph theory could be used to solve many types of problems. The essential factor is that the problem be reducible to the form of a graph. An unusual puzzle consists of four cubes whose faces are coloured four different colours (say red, blue, green, and yellow) in such a manner that each cube contains at least one face of each colour. The problem consists of arranging these cubes one on top of the other, in such a manner that each of the four vertical faces of the resulting column shows all the four colours. You can make yourself one such set by cutting out the network of the cubes on a card and painting them as shown in Fig 1.

A trial and error method would mean that one may have to try 41,472 combinations, assuming no repetitions. We arrive at the figure of 41,472 combinations in this way: the first cube can be placed in any one of three ways (since in this case what matters are the faces that are visible) and each of the remaining three cubes can be placed in 24 positions. Thus, the total number of combinations is 3x24x24x24 = 41,472. Most people spend many frustrating hours on this problem before throwing up their hands in despair.

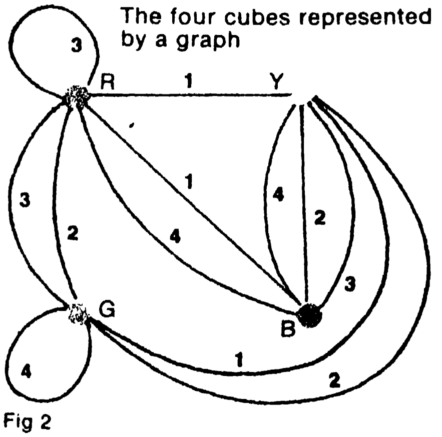
Graph theory can now be called upon to help solve the problem in a few minutes. Each of these cubes can be represented by means of a graph in the following manner. Mark four vertices to represent the four colours as R, Y, B, and G. Pick any one of the cubes and call it "1", and rep[illegible] the three pairs of opposite [illegible] the cubes by lines joining the [illegible]ate vertices. Label these lines as "[illegible]. For example, if a red face has a green [illegible] opposite to it, then join R to G and label this line as "1". A loop in the graph at R means that the red face of the cube has a red face opposite it.

Similarly, another cube from the remaining three is called "2" and its three pairs of opposite faces are represented by three lines joining the vertices of appropriate colours. These three lines are labelled as "2". The operation is repeated with the remaining two cubes, and we have a graph of four vertices and twelve edges labelled 1,2,3 or 4 (Fig.2).

Examining the resulting graph, we find that the number of lines emerging from each vertex (or what is called the degree of the vertex) equals the total number of faces of that colour. For example, the degree of the vertex R is seven and we see that there are seven faces coloured red out of the total of 24 faces in the four cubes. Similarly, the vertex G is of degree six, as is vertex Y, while B is of degree five.

We now consider the two opposite faces of the desired column (say, front and back). They are made up of eight faces of the four cubes, and can be represented by a sub-graph of Fig.2. Since each colour occurs only once in each of these two opposite faces, the degree of each vertex in the sub-graph must be two. So the problem reduces to finding a sub-graph consisting of the four vertices R, Y, B and G, such that each vertex is of degree two and the sub-graph has four edges each of which is labelled differently — either 1, 2, 3 or 4. A similar argument holds for the left-right faces of the desired column.

The problem would thus be solved if we could find two such sub-graphs—one for the front and back faces of the desired column, and one for the left and right faces. Also, since the opposite faces of any cube cannot occupy both a front-back and a left-right position, the two sub-graphs should not have any edges in common; in other words, they should be edge-disjointed.



The four cubes represented by a graph

Fig 2

MAGIC SQUARE FOR 1980

117	313	504	725	321
723	314	110	306	527
324	520	716	312	108
305	126	322	518	709
511	707	328	119	315

We welcome 1980 with a magic square in which the odd and even numbers are separated from each other. The sum is 1980 along the five horizontal rows and five vertical columns and along the two diagonals. Readers can get 1980 from five numbers in many other ways also.

Notice that 511, 520, 518, 527 and 504 are connected by knight's moves (the way a knight moves on a chess board). Also, all numbers beginning with 7 are connected to each other by one or more knight's moves. Similarly, numbers beginning with 3 or 1 are also connected by knight's moves.

Moving along knight's moves, in how many ways can you connect five numbers so that their sum is 1980? Good luck to you, and may the magical year, 1980, be a happy one.

D. R. KAPREKAR

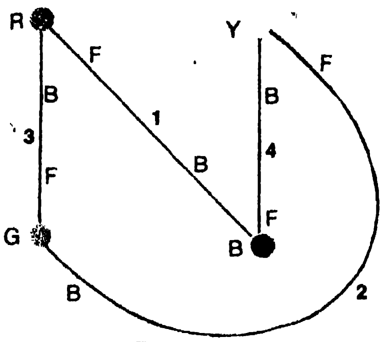


Fig 3a

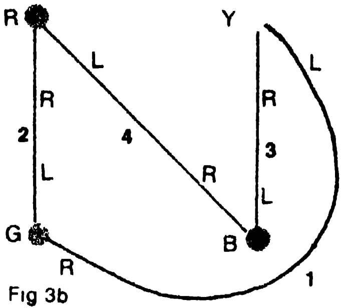


Fig 3b

Fig. 3 shows two sub-graphs of Fig. 2 which satisfy the above conditions. Using any one of these (say, Fig. 3a) for the front-back positions and the other for the left-right positions, we can now solve this problem. Starting from any vertex, we sequentially label the two end points of each line as front (f) and back (b) for Fig. 3a and left (l) and right (r) for Fig. 3b as shown in the figure. (Labelling is done in this way to ensure that if (say) cube "1" has red in the front position, then cube "3" will have red in the back position.) Using these graphs, the required stacking of the cubes can be done readily. For instance, we see from Fig. 3a that the edge marked "1" (which stands for cube "1") has red at the front end and blue at the back end.

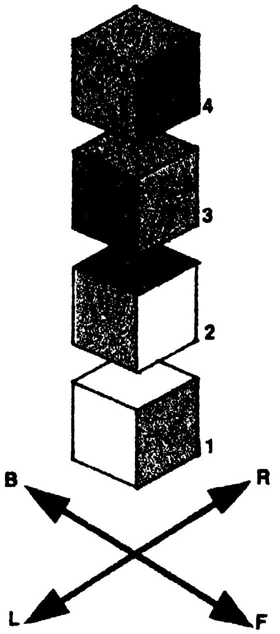
From Fig. 3b we see that this same cube has yellow towards the left and green towards the right. Proceeding in this way for all the cubes, we get the solution (Fig. 4).

Once the basic principle is known, the following related problems should not be too difficult. Can you colour the four cubes in a different way — keeping in mind that each cube must have at least one face painted in each of the four colours — and still find a solution for the problem? Are there any ways of colouring the cubes (keeping the basic condition in mind) so that no solution is possible? Can you find a way of colouring five cubes in five different colours — so that each cube has at least one face in each of these five colours — and then stack them on top of each other so that each face of the resultant column has all the five colours?

K N. MALATHI

Ms Malathi is an electronics engineer at Hindustan Aeronautics, Bangalore

Fig. 4 Solution of the four coloured cubes problem



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Jaikrishna [illegible] [illegible]

De-ashing of coal

An alkali process for the demineralisation of coal has been developed at the Central Fuel Research Institute, Dhanbad, (CFRI) (Bihar) which virtually gives a 100 per cent yield of demineralised coal. The by-products of the alkali-coal reaction can be economically recovered.

When coal is burnt, the inorganic or mineral matter associated with it leaves a residue called ash. But a high proportion of mineral matter makes coal unsuitable for most purposes, particularly the production of metallurgical coke. The limited reserves of coking coals in India (almost exclusively located in the Jharia coalfield) are fast dwindling, though the shortage is sought to be met by importing low-ash coal. Also, the prime coking and/or the low volatile medium coking coals are relatively of high ash content (25 to 35 per cent), and to make matters worse, these are most difficult to wash by the conventional methods. The yield of clean coal (which has 15 to 16 per cent ash) from such coals, is usually no more than 20 to 25 per cent. This has seriously limited the development of the iron and steel industry in the country. Even coals considered economically washable, giving an average clean coal yield of 60 to 70 per cent, produce a by-product fuel called middlings which with its high ash content, is unavoidably used as a fuel in thermal power stations.

There is also a growing need for very low-ash or super-clean coal and the premium grade low ash coke thereof, for special metallurgical purposes, including production of electrode carbon, for which the ash content of coke should preferably be well below 10 or even five per cent.

A number of physical and chemical approaches for the upgradation of coal to the levels of required purity have been developed in India and abroad.

The patented chemical process developed at the CFRI (*Proceedings of the International Symposium on Coal Science & Technology, Dhanbad, Feb. 1979, in print*) involves the use of caustic soda. Its special features are (i) fine grinding of coal is not essential, (ii) no pressure treatment, (iii) temperature of reaction is low, (150° to 160°C), (iv) yield of demineralised coal is virtually 100 per cent and (v) no deterioration in properties of coal.

The major minerals in coal are (i) kaolinite type of silicates or shales, (ii) quartz and/or sandstone, (iii) pyrites, (iv) carbonates like siderites or ankerites. Of these, the shales and the free quartz generally constitute 85 to 90 per cent of the total mineral matter. The alkali used in the process can, in principle, attack these minerals and convert them into acid-soluble form. Thus, the process in short

Fig.1 Schematic Flow - Sheet of the Process of Demineralisation of Coal

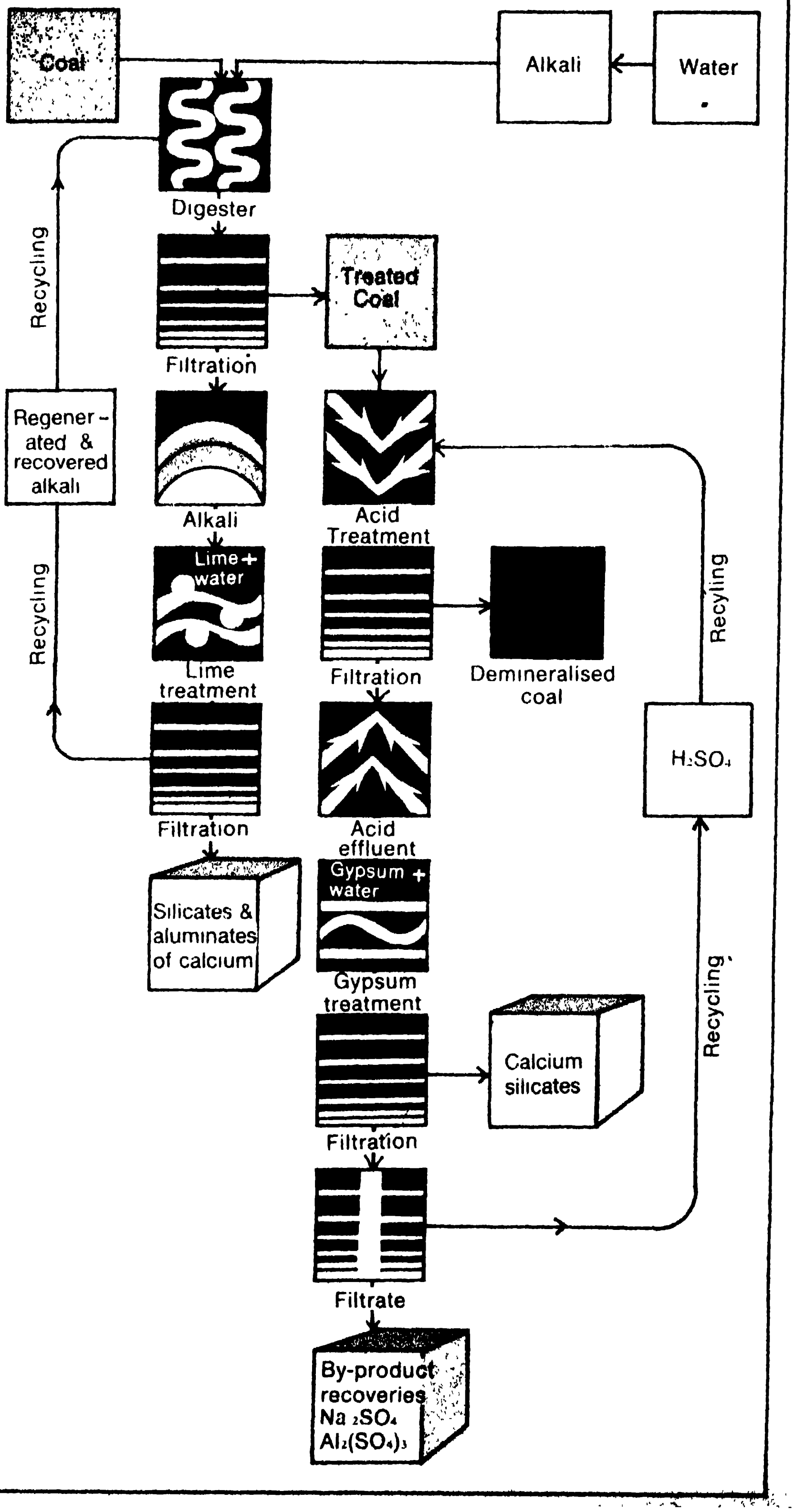

Table 1: Bench-scale studies on the process of demineralisation

A. CONDITIONS OF TREATMENT AND EXTENT OF DEMINERALISATION

Sl. No.	Coal	%Ash (dry)	Scale of treatment, wt. of coal (kg)	Conditions of treatment						Demineralised coal		Degree of demineralisation (per cent)
				Size of coal	NaOH used,% by wt. of coal	Concentration of alkali %(w/w)	Temp. °C (coal bed)	Pressure (atm.)	Time (hrs)	yield kg.	%Ash (dry)	
1.	Bararee, XIV Seam, (Coking coal)	15.4	5	x3 mm	20	70	120	1	3	4.3	6.9	59
2.	—do—	—do—	15	x3 mm	15	70	115	1	2	12.7	6.5	62

B. PROPERTIES OF COAL AND COKE PREPARED THEREOF, BEFORE AND AFTER DEMINERALISATION

Sl. No.	Coal	Prox. Analysis(%)				C.I.	S.I. (B.S)	Coke type (LT GK)	Screen Analysis, cum. % on							Prox.Analysis of coke, %			
		M	A	V	F				6 mesh	10 mesh	16 mesh	32 mesh	52 mesh	72 mesh	-72 mesh	M	A	V	F
1.	Barjree, XIV Seam																		
	(a) Original	1.4	15.4	25.4	57.8	17	8/8½	E/F	nil	3.0	15.5	51.6	70.3	77.3	22.7	0.9	20.5	0.8	77.8
	(b) Demineralised	1.0	6.9	27.1	65.0	22	8/½	G1	nil	20.6	36.6	58.5	69.0	73.9	26.1	0.4	10.1	0.4	89.1

consists in the treatment of coal with optimum proportions and concentration of caustic soda solution, followed by leaching and washing successively with acid and water to recover the valuable by-products.

The process is made economical by its efficient use of alkali, especially by its regeneration, recovery and recycling - A portion of the alkali is recovered by the treatment of the alkaline effluent from the coal-alkali reaction with lime, and then concentrated to the desired level for recycling. A good part of the alkali, however, remains in the alkali-treated coal as sodio-aluminosilicate which when treated with acid, is eliminated as sodium sulphate, aluminium sulphate and silicate acid. A scheme has also been worked out for the recovery of such by-products, in particular, sodium sulphate and aluminium sulphate, the premium for which will substantially counter-balance the cost of chemicals used in demineralisation.

The technological feasibility of the process has been studied on bench scale (Table 1) and semi-pilot plant scales. The semi-pilot plant studies were done in batches of 150 to 160 kg coal. The percentage yield of demineralised coal on dry basis ranged from 85.6 to 91.8 for different types of coal with ash content of 12 to 21.9 per cent. The degree of demineralisation was 46 to 62 per cent. The laboratory performance could be successfully duplicated in scale-up studies for easy commercialisation. A flow-sheet of the integrated process of demineralisation and by-products recovery is presented in Fig. 1.

The chemical process of demineralisation can treat all types and grades of coal including middlings having variable ash content and effectively demineralise these to any desired level of purity. Further, the plastic or the caking property of coking coals is not affected at all. Pyrites and phosphorus are also removed to a considerable extent during the treatment.

Successful commercialisation of the production of demineralised coal would largely depend on the economisation of the alkali and acid requirements, in particular, efficient regeneration and recycling of both, as well as recovery of by-products, as indicated in the flow-sheet.

Pilot plant development is presently under way but, it has been tentatively computed, based on bench scale data, that starting from high-ash coking coal, having say, 20 to 25 per cent ash content, the cost of demineralised coal with 10 per cent ash or below, would not be more than Rs. 500 to Rs. 600 per tonne. And if the premium for by-products like sodium sulphate and aluminium sulphate (the yields of whic are likely to be about 10 and 15 per cen respectively, by weight of coal), are take into account, the cost of low-ash co would be Rs. 400 or somewhat less. A against this, the reported landed cost o the imported coking coal is Rs. 700 to 80 per tonne.

The process could be straightwa adopted for the production of premiu grade coke for specialised metallurgic uses such as the manufacture of electrod carbon and allied carbon artefacts, as bla furnace injection fuel or as the feed-stoc for the conversion of such super-clea coals to oil and chemicals.

B.K MAZUMDAR and A.N SENGUPT

Mr Mazumdar and Mr Sengupta are at th Central Fuel Research Institute, Dhanba Bihar.

Brain Teasers

Landlords and Tenants

In our locality, there are four rental buildings — Ashok Mahal, Balaji Mahal, Arun Mahal and Sunder Mahal. Curiously enough, their owners' names are Ashok, Balaji, Arun and Sunder, though none of them had given his name to his own building.

The landlords have trouble with their respective tenants. They sell the buildings to one another.

In the new set-up, too, no one owns the building bearing his name. Balaji bought Sunder's house and the owner of Sunder Mahal bought Balaji Mahal. The house owned by Arun was bought by the namesake of Sunder's house. Now there is no trouble with the tenants.

Who bought whose building?

V. A. SHENAI

(Solution next month)

Solution to last month's Brain Teaser

The witty salesman

Let x be the cost of a ball pen and C the total amount paid by Mr. Panikkar. Then from the conditions given,

$$5x + 6x = C$$
$$\text{or } 11x = C$$

So, the total of the purchases must be a number divisible by 11, and also it should be less than 50. The only pairs of digits that total 8 are 1,7; 2,6; 3,5; and 4,4. The only integer divisible by 11 that can be formed from any of these pairs of digits is 44. Therefore, $x = 4$. It follows that the cost of a ball pen is Rs.4.

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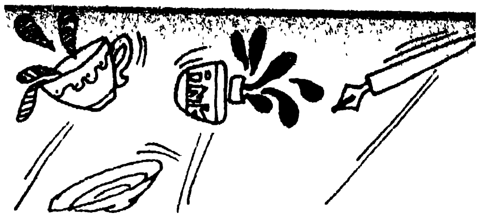

. . . there were no gravity

WHAT WOULD HAPPEN? The apple wouldn't have fallen on Newton's head, you might say. You are right, but only partly so. In the first place, would either Newton or the apple have existed?

Gravity is the weakest of the four fundamental forces. It is the mutual attraction between all matter in the universe, but it is a weak force. Let's compare it with the electromagnetic force, the force that binds the proton and electron in the hydrogen atom. This electromagnetic force is some ten thousand billion billion billion billion (that is 10^{40}) times stronger than the force of gravitational attraction between them.

Is such a weak force really necessary? Can we afford to do *without* it?

Our existence is closely linked with our environment, which in turn is linked with the large-scale structure of the universe in a very complicated fashion such that, all four fundamental forces come into play. To suppress one of them and ask for the consequences, involves a thought-experiment which is not as easy as might seem at first. However, let us have a go at it!

Let us begin at the easier end -- the small world of subatomic particles. The force which binds the neutron and the proton within the atomic nucleus is the strongest of all forces: the so-called strong interaction. It is stronger than electromagnetism by at least a factor of hundred. So gravity, because of its relative weakness, is not going to be missed by the nucleus if, in our thought-experiment, we remove it altogether. Indeed, the calculations and the experiments relating to the nuclei of atoms do not take into account the miniscule effects of gravity.

So the nucleus will stay intact. What about the atom as a whole? Here the binding force between the atomic nucleus and the atomic electrons is the force of electromagnetism. This, we have already seen, far exceeds the force of gravity. Therefore, if we eliminate gravity, the atom would not notice it either.

The same argument applies to molecules, and indeed, to the entire subject of chemistry, which is concerned with the interactions of atoms and molecules. The basic force which comes into play here is the force of electromagnetism.

Making a transition from the microscopic to the macroscopic world—from distances of 10^{-12} cm to 10^{-8} cm to the everyday sizes of centimetres and metres—let us ask how important is gravity for holding together the objects we see around us. Would tables and chairs crumble to their constituent atoms and molecules if gravity disappeared? Would we, the human beings, be reduced to atoms if there was no gravity?

Let us do a simple calculation using Newton's inverse square law of gravitation. Suppose a chair has a mass of 20 kg. Imagine that it is broken into two halves, each of 10 kg. What is the force of gravitation between the two halves? If we say that the characteristic separation size involved is about 50 cm, the force (in standard jargon) would be:

$$F = G\,\frac{m_1 m_2}{r^2} \simeq \frac{2}{3} \times 10^{-7} \times \frac{10^4 \times 10^4}{2500}$$

$$< 003 \text{ dynes!}$$

This is the force necessary to lift a weight of about 3 micrograms! If such a small force were responsible for holding the chair together, even a child could break it. Obviously, it is not gravity that is of much relevance here. Indeed, a detailed study of what holds chairs and tables (and ourselves) together, would once again lead us back to electromagnetism.

So the objects around us would not break down if gravity disappeared. True, we would not be able to stay on the earth, whose gravity keeps us all here. But, haven't our astronauts and cosmonauts demonstrated that it would be possible to live in a zero-gravity environment? So, at first sight, it seems that we could—at a pinch—live in spaceships in a zero-gravity world.

This conclusion, however, ignores the really crucial areas where gravity plays a vital role. Although small on the atomic scale, it comes into its own when the masses are astronomical.

In our present understanding of cosmogony, gravity plays a vital role in the formation of the solar system, the stars and even the galaxies. It is the one long-range force (known to physicists) which can bring together diffuse clouds of matter in the universe and form them into lumps. Depending on their size, mass and other properties, these lumps eventually become stars, galaxies, etc. So, in the absence of gravity, it is inconceivable that these objects would have formed in the first place.

It might be argued that we still do not know the details of the various cosmogenic phenomena. So let us perform another thought-experiment on the existing universe of stars and galaxies. Let us switch off gravity. What will happen? In a typical star there is an equilibrium between the force of gravity and the internal pressures. Remove gravity, and this equilibrium will go haywire. For want of the gravitational attraction, the star will blow itself apart. It will cease to exist as a self-luminous lump of matter.

While we might be able to dispense with other stars, we cannot do without our own star, the sun. Sunlight plays an important role in the origin and sustenance of life. The earth will also blow itself apart once its gravity disappears. Remove the sun and the earth and you will find no base to set up any form of life, let alone human civilisations. There would, of course, be less drastic consequences, such as the blowing away of the atomsphere if the earth lost its gravity. But I have not considered such consequences because these are secondary phenomena. The most drastic and far-reaching effect — if gravity were to disappear now — would be the blowing apart of the sun and the earth and of the consequent loss of life.

Nature as a whole poses a gigantic jigsaw puzzle in which every piece—however small it may seem--has some indispensable role to play. Gravity is such a piece. Although apparently small, it is not dispensable!

J.V NARLIKAR

Dr Narlikar is Professor of Astrophysics at the Tata Institute of Fundamental Research, Bombay

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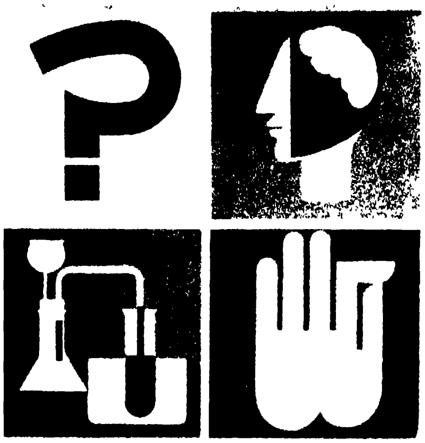

The method of science

This series, beginning with this issue, is adapted from an exhibition on "The Method of Science" which was prepared by a group of scientists, painters, photographers, film and television producers, and instrument engineers, at Hyderabad, between June 1975 and January 1977 The group was led by the Indian biologist, Dr. Pushpa M Bhargava, on an invitation by Dr Rais Ahmed, then Director of the National Council of Educational Research and Training (NCERT), New Delhi The exhibition sought to convey that science is nothing more than questions asked and questions answered, that the method of science is the method of asking questions and answering them, and that the method of science can be used to solve problems that face us in everyday life All other attributes of science emerge out of this basic attribute—that is, the right to question

The exhibition was set up in the Bal Bhavan campus at New Delhi, between February and April 1977, but was never inaugurated, though it had already been widely acclaimed in this country and abroad Even more surprising was that while Dr Bhargava was looking for another place in India or abroad to house the exhibition, the NCERT, according to Dr Bhargava, opened his lock on the exhibition on the night of 5 August 1978, and secretly dismantled the exhibition and took it away in many trucks with the help of a hundred men

The Philosophy

There are no secrets in science You can do and know all that a scientist does and knows You do not have to have any faith in him as an individual and accept what he says without questioning We do not ask you to have faith in us and accept what we have to say here without questioning The only thing we ask you to do is to base your questioning on simple untempered and uninhibited reason—the kind of reason that characterises a child on whom society has not yet imposed its beliefs and prejudices

We will try to say something about the method that science uses to arrive at answers to questions We hope that this method will also help you to find answers to your questions

Scientists, in fact, are just those who accept the method of science as the only way of finding truth, and who use this method in whatever they do

P. M. Bhargava

Introduction to the method of science

Five questions

This series is intended to help you answer these questions

What method does science use to acquire knowledge?

What are the characteristics of the method, and of the information acquired through it?

Can the method of science be applied to problems—simple or complex—that one faces in everyday life?

How would you verify whether or not a statement, a conclusion, or a piece of information is correct?

What are your obligations if you accept the method of science and the knowledge acquired through it?

Right, wrong, or answer not known?

Out of the following eight statements two statements are right, four are wrong, and in the case of the remaining two, it is not known today whether the statements are right or wrong. Read these statements and reason out in which of the three categories each statement falls For our opinion, see last column

1 Some objects can travel faster than light
2 It's a bad omen if a black cat crosses your path
3 The sun rises in the west and sets in the east
4. Water can be made from hydrogen and oxygen
5 Atoms are unbreakable
6 If you sow Sonora wheat, you will reap Sonora wheat.
7 There is life out in space
8 Family planning can't solve any problem.

You may now ask

How was the right answer arrived at?

If the answer is not known today, how will we be able to find the answer in the future?

If your answer was wrong how can we say with confidence that it was wrong?

If you would like to verify the answer, how would you go about it?

The answer to all above questions is *by using the method of science.*

The method of science allows one to obtain answers to questions.

4 6 are right 2 3 5, 8 are wrong 1 and 7 we do not know today whether right or wrong

NEXT MONTH

The four distinct steps in the method of science—

QUESTION — HYPOTHESIS — EXPERIMENT — ANSWER

Initially sponsored by the National Council of Educational Research and Training New Delhi The Method of Science Exhibition was largely financed by the Vazir Sultan Tobacco Co Ltd Hyderabad the Regional Research Laboratory and the Upagraha Doordarshan Kendra at Hyderabad gave institutional support Dr Bhargava also received financial support gift of material professional advice, and assistance in many other ways from a large number of individuals institutions and organisations in India and abroad

Credits Text and direction Dr Pushpa M Bhargava and Mrs Manorama Bhargava drawings and paintings Laxma Goud and A. Shareeff films and videotape, P V Satheesh photography M Hasan and Dr (Mrs) Kaiser Jamil experiments and sound effects Dr M W Pandit models and instrumentation P S Kolhatkar B Gopinath and Sanjar Ali Khan construction and display, Surya Prakash

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SIMOES/AG/6/79

A People's Science Movement in Kerala

V.K. Damodaran

It began as a forum of popular science writers and has grown to emerge as a mass movement that aims to use science to achieve a social revolution

By 2 October, 1977, a team of about 40 people, including many doctors, engineers and scientists, had gathered in a village near Kasaragod, at the northern end of Kerala. Just 37 days later, the team, whose composition kept changing along the way, had travelled 11,000 kilometres by district and village roads, sometimes even off the road, to reach the southern tip of the state. In between, they spoke at over 840 receptions, addressing about half-a-million people on themes such as, 'science for social revolution', 'labour power - the greatest wealth', and 'state administration in common man's language'. This unique jeep *jatha* (procession), organised by the Kerala Sastra Sahitya Parishad (KSSP), was enthusiastically received by villagers everywhere. A broad-based people's science movement was emerging in Kerala.

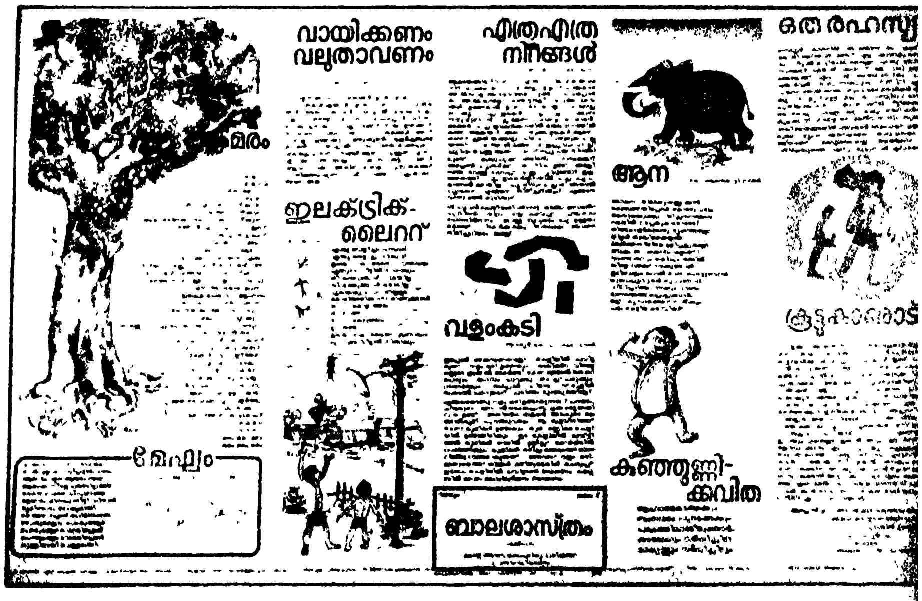
Not that the programme itself was totally new. But it hadn't been done on such a large scale earlier. In fact, the Parishad, which originally came into being as a forum for popular science writers in Malayalam in 1962, had organised several programmes earlier, to popularise the slogan 'science for social revolution'. Today, the Parishad has over 3,000 members on its live roles and about an equal number of affiliated organisations like rural science forums, science societies and school science clubs. The Parishad brings out five science magazines and the influence of its activities is felt all over Kerala. Over a million students, teachers, workers, farmers and technicians have had some sort of contact with the Parishad and the activities it has undertaken.

The Parishad's activities have to be seen in the context of Kerala's high literacy rate (60.4 per cent). This high literacy is itself the result of two factors. Firstly, during the latter half of the nineteenth century, there occurred a rapid expansion of the formal education system. On the other hand, during the freedom struggle a non-formal education movement, known as the 'library movement', developed as part of the educational activities of radical political parties. The library movement culminated in the formation of a central apex body, Kerala Granthasala Sangham, which had 4,500 affiliated village libraries and probably an equal number of smaller village libraries without affiliation. These libraries also formed cultural centres in villages and through them the Granthasala had a fairly long experience of conducting functional literary classes for adults in villages. Therefore, reading, or at least newspaper reading, had come to stay in Kerala as a matter of habit.

Given this background, the first activity of the Parishad was to forge a front of effective popular science writers and to encourage the creation of popular science literature in Malayalam, the language of the state's people. Keeping this aim in view, the organisation was obliged to start a publication on its own initiative since the established media offered little encouragement to such concepts. This publication, started in October 1966 as a quarterly called *Sastragathi* (Trend of Science) was exclusively devoted to science. The journal survived and in due course became a powerful instrument for organising other activities. Its general acceptance led to its periodicity being increased to a bimonthly and later to a monthly.

Though people from all walks of life—teachers, doctors, engineers, social workers, agriculturists, journalists, the unemployed youth—have found in the Parishad a useful common platform, the student community has remained the largest group with which the Parishad is connected. The Parishad's work among the students gained momentum with the 'one thousand science club campaign' in 1973. This has resulted in the formation of a large number of school science clubs throughout the state. The school science clubs eventually attracted school teachers also to the activities and ideals of the Parishad, and now they form a considerable proportion of the Parishad's activists. The attention of parents was also drawn to the Parishad by having programmes for interested parents. The idea caught on vigorously and now there are a large number of primary school science corners, high school science clubs, college science forums and youth science societies in Kerala.

Meanwhile, the number of students attracted to the Parishad grew to a few thousand and they wanted *Sastragathi*, the only Malayalam science magazine till then, fully for their own use. They were not satisfied with the limited number of pages set apart for each age category of readers. This, as well as our experience of using *Sastragathi* to strengthen the organisation, led to the publication, in 1969, of the second of our science periodicals, *Sastra Keralam*, intended



Bala Sastram, a science wall paper for children for children below 15 years. Publication of two or three popular science books per year was also attempted during those formative years.

Gradually, our workers in the field sensed that primary school children needed a magazine of a still simpler standard than the *Sastra Keralam*. Thus in 1970 came the children's science magazine *Eureka*, which with a circulation of 45,000 now commands the largest circulation among all the five science journals brought out by the Parishad. This was by no means the end because early in 1979, we embarked upon the publication of a science wall paper (size 90 x 58 cm) *Bala Sastram* for children under nine years (see photograph on p.49). Profusely illustrated in full colour, it is published eight times a year, during the months when schools are open. The paper's cost is kept low since it is designed to be hung up in schools to enable a large number of children to read it.

Since useful reading material was now being made available in their own language, many students from comparatively poor sections of the community were also reading extensively on science topics We realised the necessity of arranging some regular contests for these children, and tests like the *Sastra Keralam* science quiz (conducted in three stages), in which every year a total of not less than 60,000 high school children compete, and the *Eureka* science talent test in which over three lakh primary school children compete, were organised. Based on their performance in these competitions and such other tests, several prizes, trophies and scholarships are given to winning students.

Another challenging exercise, called *Sastragathi Vigyan Pareeksha*, is offered exclusively to college students. 200 questions covering all branches of knowledge are prepared by experts in the respective fields. The students are given one full month to answer the questions. All the questions have to be answered in the given sequence. To face this test, they may have to read a large number of books and consult several teachers and professionals of various disciplines and digest what they have acquired. A few hundred college students consider this challenge worth facing every year.

Emerging as a movement

While the Parishad's activities among students are primarily aimed at generating an increasing awareness and interest in science, they have also had the effect of drawing a large number of students and teachers into the Parishad. This has in turn helped us to launch wide-spread mass communication campaigns involving larger sections of the community.

The first such major attempt to take science to the people and reach them directly was made in January 1972. Three streams of scientists, starting from three ends of the state, moved by road and converged on the venue of the ninth annual conference, en route lecturing on science and society, the plight of scientific research in the country, problems of development, and other such topics. During this three-day sojourn, several street corners, weekly markets and school sheds, besides village libraries, universities and advanced centres of learning, were utilised for these lectures. Though many educated people shrugged in disapproval, a large cross-section of ordinary people welcomed the 'science pilgrims' with garlands and applause. More important for us, was that this experience exposed scientific workers to the people and their problems for the first time. Though the contact was fleeting, it enabled the emergence of a hard core of volunteers adept at taking science to the people. Thus, the experience was invaluable.

Next year we decided to enlarge the scope of these lectures. The first week of January was declared as science week and 1,000 popular lectures were proposed to be conducted throughout the state on three topics: the universe, the development of society and the growth of science. The response of the people exceeded our expectations and 1,500 classes were conducted instead of the target of 1,000. This showed that there exists a real need for such public debates on topics of social relevance. Even progressive political parties having considerable influence in the state did not cater sufficiently to this need, and it was this void the Parishad was trying to fill in.

Following this lecture programme, there was an intense debate within the Parishad on the role of science in social change. The dominant view within the Parishad is not in favour of merely restricting its activities to 'knowledge transfer'. The underlying perception of the Parishad was one of developing a scientific attitude among the people so as to ensure their effective participation in the process of development. The method of operation was conceived not in terms of a one-way relationship of reaching the people with a given fund of knowledge, but of consciously interacting with them in a process of sharing knowledge and experience, and forging ideas. The Parishad is bent upon establishing a social climate conducive to the acceptance of scientific methodology. We feel that people should be made to act for themselves and the Parishad workers strove to be catalysts in this social transformation. This attempt invariably involves a long period of gestation before it can show any perceptible results.

The enthusiasm aroused amongst the public by the one-thousand-lecture programme was such that several questions were asked and many lively discussions took place. This was the second critical input towards the Parishad's metamorphosis into a people's science movement. This was evident in the subsequent programme emphases. Almost every following year a major mass contact programme, in the form of *jathas*, study classes, exhibitions, etc was planned to be conducted. In all our programmes the plans emerge from the experiences of direct contact. Qualitatively, we plan for what we have, but quantitatively for a little above what we can. And our experience has been that we were never too off the mark. At the planning stage, we realise that, with a little extra effort, the target could be achieved. Our workers don't resent this additional strain. Instead, when the target is achieved it gives a tremendous boost to the confidence of the voluntary workers.

Science month

These initial mass contact programmes led to a more concerted effort to mobilise and involve the people in the activities of the Parishad in 1976. Based on a month-long programme of study classes in different parts of the state, a popular science book on *Nature, Science and Society* was prepared after detailed discussions within the Parishad. Nearly 1,500 people, some of them coming into contact with the Parishad for the first time, were enlisted as volunteer-teachers and were given training on the conduct of the classes. January 1976 was declared the 'science month' and arrangements were made to conduct 3,000 classes. Though the theme of the classes had no well-defined boundary lines, the simply written, small book prepared for the purpose proved to be of great help.

The classes were mainly conducted in the villages, in schools and village libraries. The audience consisted mainly of agricultural and non-agricultural workers and farmers, both old and young, men and women, as well as school students. The classes aroused both their curiosity and (in some cases) opposition. Curiosity, because most of them had never had an opportunity to learn about phenomena like the origin of the earth, its place in the universe, the evolution of man, his struggle for survival through the different stages of history, leading to the modern age where in spite of all the scientific and technological knowledge at man's command, the world continues to be inequitable and exploitative. Opposition from some, especially the old, because these classes did not refer to God even once, whose creations, they thought, were the rains, and the day and the night, and all the phenomena of nature. Their deep-rooted superstitions and dogmas presumably clashed with what the young men from the Parishad were telling them. Arguments ensued and the classes became increasingly lively. Once their curiosity was aroused, the people wanted to hear and learn even more, and the teachers had no other way than to yield to their demands. Such a 'dialogic process' appears to have been responsible for the multiplication of the classes to 12,000 within a month, exceeding the targeted number four times.

Clockwise from left: Sastrakeralam, Eureka, Grama Sastram, a procession through a village

Opposition from some, especially the old, because these classes did not refer to God even once, whose creations they thought were the rains, and the day and night, and all the phenomena of nature. Arguments ensued and the classes became increasingly lively. Once their curiosity was aroused, the people wanted to hear and learn even more

It is estimated that nearly a million persons attended these classes, the number of classes conducted per volunteer-teacher ranging from one to 30. Only the cost of printing the book was borne by the Parishad; the cost of travel was met by the volunteers themselves.

The next lecture scheme to follow was on 'The wealth of Kerala'. A special text which highlighted the prospects and problems of Kerala's economic development was prepared as the core material for the seven-day-long discussion programme. Though the 5,000 such discussion groups which met in stray remote villages of Kerala fell short of our target, this was really the stage when even the state administration took the Parishad as a force to be reckoned with. The ability of the Parishad to interact effectively with the public was established beyond doubt. Especially since this was the first ever discussion in our country, on resource utilisation, involving the people concerned directly into it. Among the issues discussed was the rightful place of public opinion, local resources, and the aspirations of the people, in the planning process. As a result, people agreed on the need for preparing a local development strategy and knowing more about the prevailing developmental process.

The tempo created during this period was utilised to organise more village science forums. Many of these forums are organised under the initiative of the Parishad while others were formed at the initiative of the people themselves. All of them are maintained as independent bodies. The aim is to have at least one forum for each of the 981 panchayats in the state. So far, more than 600 forums have already been formed though only a few of them have demonstrated the capacity to function autonomously. The existing village libraries and primary schools in Kerala were the centres around which the forums were formed. These forums were intended to provide the base for the people in the village to undertake activities ranging from the organisation of non-formal education classes to cultural activities and starting of small industrial ventures in villages.

In order to keep up the tempo generated during this period, a plan to have classes conducted on a continuous basis was worked out the same year. The theme selected for the classes related to the problems and prospects of Kerala's agricultural development under the title, 'Agriculture in Kerala'. A popular book was prepared by a group of scientists and camps to train the volunteers were conducted in different places. By the end of 1976, nearly 12,000 such classes were conducted. The services of agricultural extension officers and other people working in development departments were utilised wherever their help was available and found useful. The experiment proved that the people are highly receptive to new ideas and willing to involve themselves in such activities if they are properly organised.

Adult education

For the past three or four years, the Parishad has been trying to articulate the issues involved in adult education and post-literacy programmes. This is an area where the library movement had gained some experience. Nevertheless, we feel this to be the most challenging programme undertaken by the Parishad. The first lesson we learned from this experiment is that one has to free oneself from all conventional notions attached to formal education if one wishes to give effective non-formal education to illiterates. No process of learning is possible for them unless their own social idiom and vocabulary are used and unless the subjects taught are related to their real-life problems and have, whenever possible, a technical overview.

A broad curriculum was formulated after long discussions in workers' camps and planning workshops. The curriculum comprised four topics: our health, peasant's economic geography, village development, and the history of mankind. The details are worked out with great care and are suitably modified whenever necessary. No formal methods, like first reading and then writing, are insisted upon. Instead, both the form and the content of the teaching are sought to be integrated with the learning of the four topics mentioned. Our experience indicates that the success of the programme depends upon the motivation and social commitment of the 'teacher-initiators' who must come from the village itself. The challenge consists in identifying and motivating such 'peers' and encouraging them to continue.

The Parishad is strongly opposed to the permanent introduction of external stimuli in place of these peers since the ultimate idea is to make the villages self-sufficient. This is one reason why progress in this programme has been slow. In at least a few villages, the results have been encouraging and the outlook of the villagers has been altered to the point where they are willing to act jointly on all matters affecting the village, especially during periods of epidemics and agricultural pest infestations. In many other villages the programmes have not succeeded and we are, at the moment, trying to analyse the reasons for the success or failure of the programmes.

These programmes are organised under the leadership of the rural science forums with the assistance of the district-level committees of the Parishad. The active participation of the village science forums is, we feel, very necessary both for the success of the programmes and for the effective continuation of the forums. We maintain communication with the rural science forums and the rural public through our monthly journal, *Gram Sastram* (Rural Science). Though *Gram Sastram* has proved to be a useful medium for the last two years, it is not yet as popular as we had hoped. Perhaps, it can be made more relevant through a greater emphasis on appropriate technology and health.

The Parishad's efforts in non-formal education also include a School for Technicians and Artisans (START). The rationale for START was that even though many technicians and artisans are very good with their hands, they have no opportunity for acquiring the theoretical knowledge that underlies their skill. The first course, for electrical wiremen, was attended by over a thousand practising wiremen. A similar course for press workers was also very successful and we soon intend to have courses for automobile mechanics, concrete workers, electricians and linemen. The courses are conducted in the evenings, and though there is a general syllabus, there are no examinations, or fixed time-schedules. The classes are arranged to be held in places where 30 or more workers come forward to attend the classes.

An organisation like the Parishad cannot but take a keen interest in the basic problems of our society and suggest possible solutions. Each year, as a part of its annual conference, the Parishad convenes academic seminars on at least one such issue. A multidisciplinary team of scientists visits relevant areas in advance and prepares a draft paper. Some of the topics taken up recently have included: relevance of appropriate technology, development problems of Kuttanad (a low-lying, water-logged stretch of land, which is also the second largest rice cultivating area of the state), development problems of Wynad (a predominantly tribal area in northern Kerala) and the development potential of Idukki district. The reports are finalised after discussion, published, and then submitted to the concerned authorities for their consideration.

In order to illustrate what such studies can achieve, I would like to consider two examples in greater detail. In the first instance, pollution from a pulp mill near Calicut had created a grave ecological situation. The health of the villagers and their cattle was seriously affected by the pollutants and their traditional occupations of fishing and farming were threatened, since coconut plantations did not yield fruit and the fish died in the polluted water. The attempts of the region's villagers to bring these facts to the notice of the concerned authorities were ignored in the beginning, because of the factory management's power and influence in the area. The Parishad took up a detailed health survey and published its findings. Several meetings were held to inform the public on the nature and the complexity of the problem. As a result, the state government had to order closure of the factory during periods of scanty water-flow in the river. The factory management was finally pressurised by the public to arrange for pollution control measures. Though the work hasn't yet started, the public awareness created is of great significance.

The second case, which is more controversial, concerns the building of a hydroelectric project in Silent Valley, a region in Kerala that is the last remaining substantial stretch of tropical evergreen forest in the Western Ghats (see SCIENCE TODAY, October 1979, p.13). The Parishad is aware of the ecological imbalance created by the Idukki hydroelectric project (first stage completed in 1976). However, we feel that the Silent Valley forest is more precious and the proposed project's benefits could be achieved by alternative means. The Parishad generated a public debate on the issue and the matter was taken to the Kerala high court by the Save Silent Valley Society and the Friends of the Trees Association. This is the first major environmental issue in India which has come up for judicial settlement. The Union government has recently also asked the state government to abandon the project because of the pressure of public opinion generated against the project.

We have also held several hundred environmental education classes for the general public and 150 volunteers have been trained for the conduct of these classes. The Parishad also takes up issues like indiscriminate felling of trees and unhygenic dumping of urban waste at the local level.

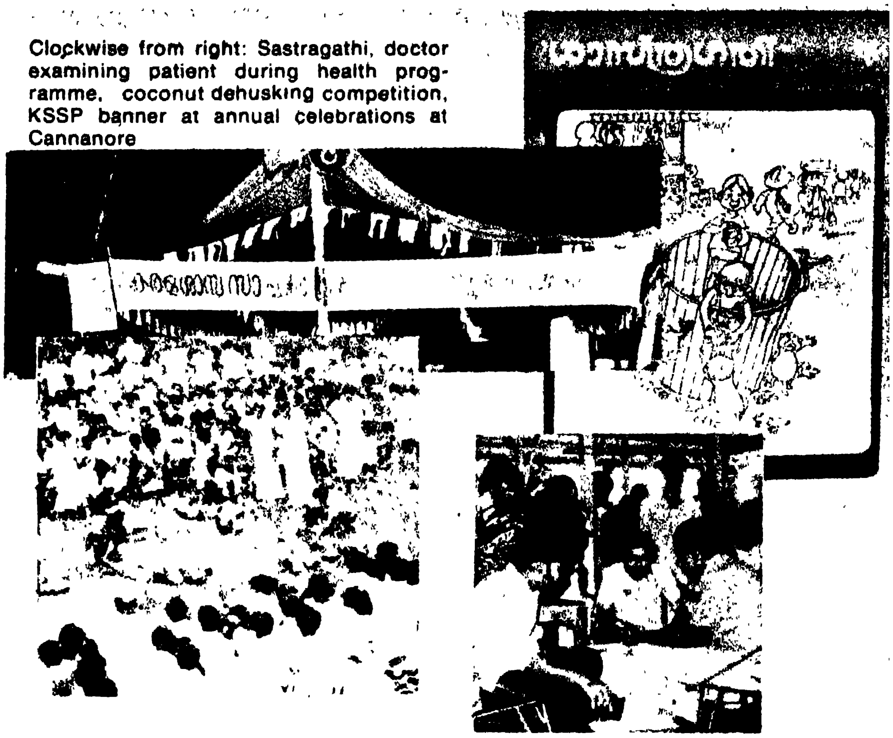
Meanwhile, work is continuing in other areas as well. The Parishad has started a science book club that is sustained by more than 2,000 advance subscribers. This scheme offers over 200 pages of new reading material to subscribers each month. A series of 50 science books for children is under preparation (20 books have been released so far). A science encyclopedia for children is being prepared and is scheduled for publication in 1980. Since these activities require gifted science writers, several workshops are conducted to ensure a steady increase in the number of writers available. Work has been started on a rural academy to study rural problems and train voluntary scientific workers to function in villages. A regional science centre is being set up at Calicut. A library and a centre for documentation and indexing of scientific periodicals are to be set up at Quilon. Both these establishments are now working on a limited scale. A mobile audio-visual science popularisation unit has started functioning recently.

The way we do it

A question often asked by visitors and newcomers to our centres of activity is: 'How do you do it?' Though the organisation collects only a nominal annual fee of Rs.5 as membership dues (open for people above 18 years of age) and Rs.100 for life membership, only a few thousands have joined as members and availability of adequate funds is a problem. Assistance from governmental agencies comes only occasionally for some specialised projects. Public donations form the largest source of funds, though we also generate income through the sale of our books and magazines.

Problems are taken up by the Parishad after suggestions are made in committee meetings and conferences. Planning is done collectively by the central executive committee, which also has all the district secretaries as ex-officio members. Voluntary groups and members at various scattered centres manage the journals, book publication work and the other major projects. The various programme sub-committees (one each for publication, health and environment, formal education, non-formal education, and rural science forums) chalk out details and set the required number of volunteers in action for each of the programmes. There are over 160 local organisational units, 30 regional committees, 11 district committees and finally the 50 member central (state level) executive committee. The village science forums do not have direct organisational link with the committees, but have only operational links. The office bearers all work on an honorary basis and do not remain in the same post for more than two years.

Clockwise from right: Sastragathi, doctor examining patient during health programme, coconut dehusking competition, KSSP banner at annual celebrations at Cannanore



Our experience indicates that the success of the programme depends on the motivation and social commitment of the teacher-initiators who must come from the village itself... In at least a few villages, the results have been encouraging and the outlook of the villagers has been altered to the point where they are willing to act jointly on all matters affecting the village

Many problems remain. The greatest difficulty lies in our inability to spread ourselves to each and every village. In some villages we could not identify suitable peers. In other villages, where the responsibility was taken up by unemployed youth, we found that many left on getting employment outside the village.

We have also found that in most centres the activities tend to centre around a few individuals. This can lead to problems when these individuals are not able to devote much effort to the Parishad's activities because of various other claims to their attention—like when they have family problems, or want to better their employment prospects, or go in for higher studies, or are transferred out of that area. We also consider the shortage of women activitists to be a major drawback because we are not able to reach as many women in the course of our activities as we would like to.

Even if we never felt a dearth of men or resources to generate ideas or execute mass contact programmes, other problems would remain. Our work displeases many powerful people because we act on unconventional lines and question established values and bureaucratic decisions. It requires patient and slow groundwork before we can raise controversial issues. There are still many groups of people who remain skeptical of or even alienated from our activities, and we consider it a challenge to be able to convince them.

Many other challenges lie ahead of us—challenges that lead to many questions.

Since the achievement of a social revolution is an important programme of radical political parties, how are non-partisan voluntary organisations such as the KSSP to take a rightful place in the process?

By organising welfare activities, are we working counter to the preparation of the people for a meaningful social revolution? Is our belief, that the right proportion of other activities will not deter us from our goal, justified?

On the health front, we are on the verge of advocating a cheaper health delivery system. A people's health movement is on the anvil. How will the establishment respond to this move?

We have, for the first time in the country, an expert and informed non-official corps of workers who can question decision-making and planning preferences on the possible options in science and technology. Can our will to carry on survive the inevitable clash with the establishment?

Ours is not a movement of the intelligentia *for* the people, but a movement in which both the intelligentia and the masses share common experiences and try to understand each other. We would like similar movements to start in other parts of our country and other developing countries as well. After our convening an All India Convention of People's Science Movements at Trivandrum in November 1978, we are sure that there are at least a few dozen such potential groups with whom we can exchange ideas and experiences. This has enabled us to ask one crucial question. Is our movement growing? Yes, and so are the challenges we have to face.

Mr. Damodaran is President of the Kerala Sastra Sahitya Parishad and has been associated with the Parishad from 1965 He is also Assistant Professor of Electrical Engineering at the Calicut Regional Engineering College.

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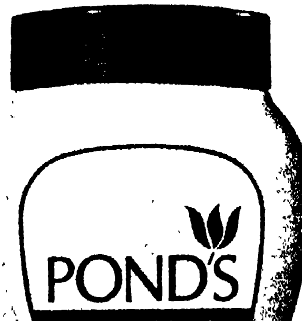

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The Bombay Mathematical Olympiad 1979

A NEW interschool competition was held at the Tata Institute of Fundamental Research, Bombay, on 8 December 1979. Two hundred and thirty, ninth and tenth standard, students met to match their mathematical skills.

Thirty-one students were selected for the finals to be held later. In one and a quarter hour they had to solve the 20 problems given below. For every correct answer they scored three marks and for every wrong answer, they *lost* one mark. The highest scorer, a ninth standard student, got 52 marks.

1. If a and b are two numbers and $a + b \quad 5$ and $1/a + 1/b \quad 5/4$, and $b > a$, then :

A. $a \quad 2$. $b \quad 3$. B. $a \quad 0$, $b \quad 5$. C. $a = -1$, $b \quad 6$. D. $a = 1$, $b = 4$.

2. For all odd numbers n, the number $n^2 - 1$ is :

A. odd. B. divisible by 2 but not by 4. C. divisible by 4 but not by 8. D. divisible by 8.

3. The product of three consecutive integers is :

A. divisible by 2 but not by 3. B. divisible by 3 but not by 2. C. divisible by 6. D. none of the above.

4. If $m/n - 5/6$, then what is $3m \quad 2n$?

A. 0 B. 2. C. 7. D. cannot be determined from the given information.

5. Bacteria of a given type double their number every N minutes (that is, if you see 6 bacteria at a given time, you will have 12 after N minutes and 24 after another N minutes and so on). Starting with 4 bacteria, one gets 1,024 of them in 4 hours. Then N is

A. divisible by 4. B. a multiple of 10. C. an odd number. D. divisible by 13.

The next four questions are similar. You have to examine three given numbers and choose a fourth integer so that the four form a meaningful pattern. (For example, given 10, 15, 20, N, you can guess that N should be 25.) After guessing the fourth number, you must choose (match it with) one of the alternatives A, B, C, D shown against the four questions.

6. 21, 24, 28, N	A. N is divisible by 7
7. 9, 25, 73, N	B. N is a cube of a number and < 100
8. 65, 52, 37, N	C. N is a multiple of 10
9. 216, 36, 6, N	D. N is divisible by 11

10. If 5 tractors can plough 5 hectares of land in 5 days, how many tractors are required to plough 100 hectares in 100 days?

A. 100. B. 50. C. 20. D. 5.

11. How many times do the two hands of a clock meet in 12 hours?

A. 12. B 11. C. 10. D. 9.

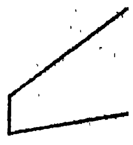
12. P, Q and R are positive numbers and given that $Q > P$ and P is not greater than R. Can $R \quad Q$?

A. It is impossible. B. $R \quad Q$: it is essential. C. R may be equal to Q; but it is not essential under given conditions.

13. Given $2(X - Y) < Y < X < 2Y$. Which one of the following is true?

A. $2X < Y$. B. $Y < 0$. C. $X < 3Y \; 2$. D. $(X \quad Y) > 3Y \; 4$.

14. Find values of X and Y satisfying A. $Y \leqslant 3X + 4$, B. $Y \geqslant X \quad 2$. C. $10 \leqslant X \leqslant 20$ and for which $X + 3Y$ reaches the highest value. The values of X and Y thus specified define one of the points a, b, c, d in in the picture. Which one?



15. If ABCD is a square inscribed in a circle of radius 1, the product AB. AC. AD is :

A. 1. B. 2. C. 4. D. none of the above.

16. If two equal chords of a circle meet at P, then any other chord of the same length through P is :

A. necessarily a diameter. B. a diameter if P is the centre. C. not possible for any point P.

17. Five points a, b, c, d and e on a map have distances as follows: ae de cd ca; ad ec; ab - be; eb bd; eb > ec. Which one of the following is true?

A. b is outside acde. B. ab < be. C. eb < db. D. ab < ad.

18. Five points a, b, c, d and e are given on a plane of which no three of them lie on any line. Any two of these points are joined by a red or blue line in such a way that no red or blue triangle is formed. Then through everyone of these points

A. pass only one red and two blue lines. B. pass only one blue and two red lines. C. pass two red and two blue lines. D. none of the above.

19. We are given a set of balls, each of which has a certain size and colour. If among these there are at least two of different colours and two of different sizes, then

A. all of them have colours different from one another. B. all of them have sizes different from one another. C. at least two differ in colour as well as in size. D. none of the above.

20. Three children X, Y and Z have a ball, a pen and a pencil and each child has just one object in hand. Among the following statements, only one is true and the other two are false.

X has the ball. Y does not have the ball. Z does not have the pen. Using this information, find out who has the ball A. X. B. Y. C. Z.

For answers turn to page 61.

The Mathematical Olympiad was conducted by the Bombay Association for Science Education and St. Joseph's High School, Colaba, Bombay.

ITS HISTORY

"THE MATHEMATICAL olympiad" has its origins in the Eotvos competitions, the first of which was held in 1894 by the Mathematical and Physical Society of Hungary in honour of its founder and president, the physicist Baron Lorand Eotvos. These contests are held every year even now, perhaps under a different name. The pattern is as follows: "The problems are almost all from high school material (up to solution of quadratic equations, plane Euclidean geometry—triangles and circles—and a little trigonometry but no calculus. They are of an elementary character, but rather tricky, and their solution requires a certain degree of insight and creative ability. Any amount of aid in the form of books or notes is permitted."

The Hungarian model was taken up by the Soviet Union. They called it Olympiad to stress its Olympics spirit. In Russia, however, two types of competitions are held: one for the children of seventh and eighth standards and the other for tenth and eleventh standards. In the USA, the Putnam mathematical competitions are held along the same lines every year for final year school students.

Why should the young mind be willing to make this effort? We quote the Eotvos winner Szego's answer: "The explanation is probably the instinctive preference for certain values, that is, the attitude which rates intellectual effort and spiritual achievement higher than material advantage.... of transmitting to young minds the beauty of intellectual work and the feeling of satisfaction following a great and successful mental effort."

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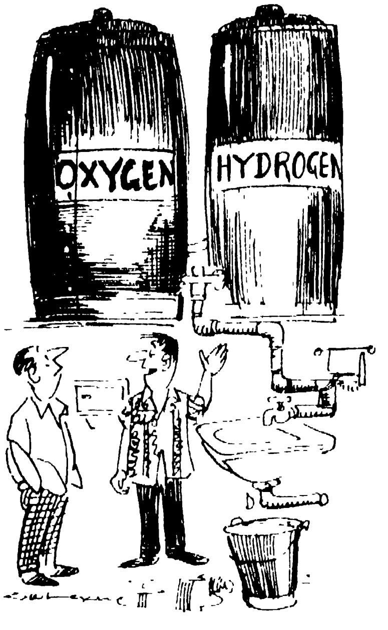
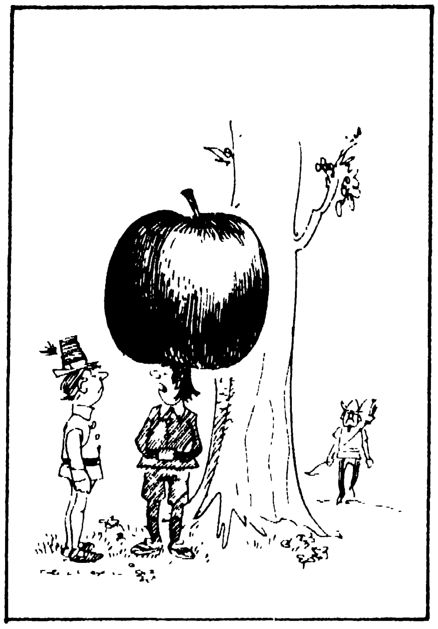
This World of Science!

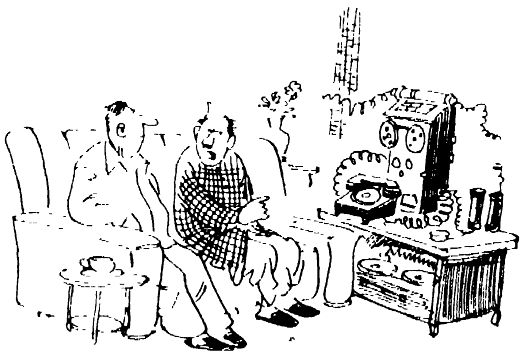
by R.K. Laxman



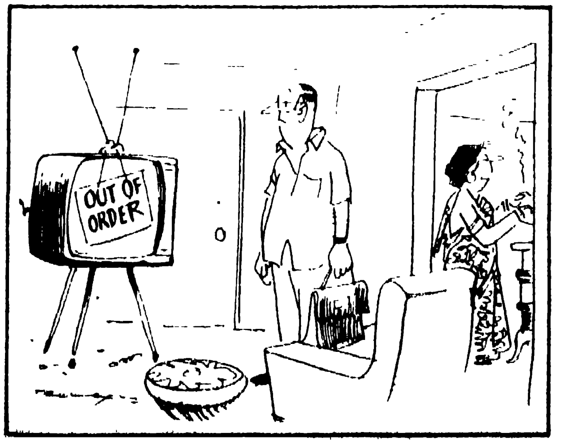
The municipal water supply became so bad I thought of an easier way



It took a lot of trouble super phosphate, processed bones, potassium salts etc.etc Dad's a lousy shot you see



They can't fool me It is a bugging device Otherwise why did they have to come and fix it the moment I resigned from the cabinet?



The expert repair chap you sent was here Worked for nearly four hours and fixed it!

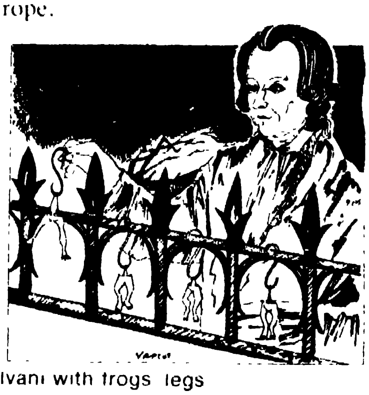
In Lighter Moments

Asides are an interesting feature of drama, used often to get things straight to the audience and help the plot thicken. The best lines of many dramatists were written for wise, if not desperate, asides. But, perhaps, the most classical of real-life asides on record came from a white-bearded old man whose unconventional mind had got him into trouble. Galileo Galilei, kneeling before the terrible tribunal, and forced to make a public "confession", spoke the words he was told to speak. "I, Galileo Galilei, ... abandon the false opinion. . that the sun is the centre and that the earth moves around it... I abjure, curse and detest the said errors."

Then came the great aside, which somebody standing nearby heard Galileo mutter to himself, "*E pur si mouve*", which when translated into English should read, "Nevertheless, it does move (around the sun)" Galileo decided he must continue to oppose the Ptolemaic theory at least privately, if not publicly. (Only last month, some 350 years after the Roman Inquisition took Galileo to task, did the Catholic church officially grant Galileo a sort of reprieve Pope John Paul II issued a statement to " make disappear the obstacles in the Galileo case")

Recently environmentalists in America cried shame when science caused a rattlesnake dish to be removed from a restaurant's menu card (see Science Shapes Life, December 1979), which in turn resulted in the dismissal of an earnest herpetologist

Science causing such changes *a la carte* isn't new In the late 18th century, there appeared an acute shortage of frogs' legs, considered a great delicacy all over Europe. Many of the best restaurants, it is said, had to take the dish off their menu. Only the enlightened of the day could understand where they went: Frogs' legs had become a standard equipment for dissection experiments in the laboratories of Europe.



Galvani with frogs legs

Among those who found the new uses for these legs were Luigi Galvani and Alessandro Volta. Galvani was a university professor of anatomy and Volta a professor of physics. Nobody lost their jobs then

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How comfortable is your chair?

Krish Pennathur

Designing furniture for the 'average'-sized person is like having only one standard size of bush shirts for all males in a region

WE SPEND a great deal of our time sitting—at work, while travelling or just resting. Sitting relaxes the muscles of the feet, legs and, to a certain extent, those of the trunk. If it is a chair one is sitting on, then how relaxed one feels will depend on the size and type of the chair: whether, while designing the chair, due regard was given to the user's physical stature as also the nature of his calling.

How does one sit on a chair? It is not just a question of bending your knees and lowering yourself down. The most comfortable way is to sit back into the chair and make use of the back-rest. The feet should touch the floor with legs approximately at right angles to the thigh. This ensures a maximum contact between the body and chair. The larger the resting surface, the lesser will be the reactive pressure on the body per unit area.

When a person is small for the chair, he tends to sit at the front edge. In this position, the front edge of the chair presses against the soft tissue of the mid-thigh. This may cause nervous congestion and lead to pain in the knees and lower legs.

So it is not correct to say that, after all, a chair is a chair is a chair. A chair suitable for clerical work will be totally inappropriate for a telephone operator. The nature of the operator's task requires him to lean forward most of the time. His chair also needs to be provided with a certain amount of swivel.

When a person has a 'sorter's' job, he is required to move along a very long table. His traverse goes far beyond the normal reach of his hands. Here, a working chair with castors will be more useful.

The draughtsman in a drawing office does not have much use for a normal type of office chair. He needs a high swivelling stool of adjustable height.

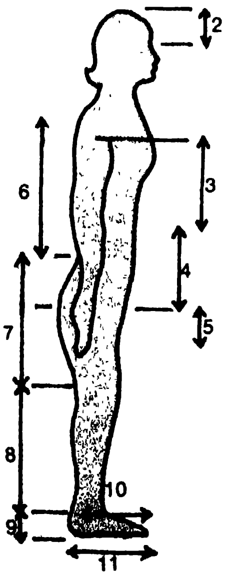
The senior executive has to cope with a lot of mental load. To him, physical discomfort can be both distractive and irritating. He needs the maximum comfort conditions to do his acute mental work. This is the reason why the executive chair is well-padded, equipped with forward, backward and round swivels, well-cushioned back and arm rests and is fitted with castor wheels.

These are but a few examples of why the common chair needs to be 'tailored' to the user's specific work-requirement.

Designers perceive these requirements in terms of so many 'loads': the physical load of the user's body on the base of the furniture, and vice versa; the perceptional and the mental loads experienced by executives; etc. And to determine the proper measurements for his furniture, he collects detailed data on the body measurements of the users. These are known as anthropometric data.

While data on the dimensions of the human body, as applicable to their nationals, have been collated in the western countries, similar data with respect to Indians are not readily available. Some work in this direction had been undertaken by the author with respect to male industrial workers in Uttar Pradesh (Table 1). But, this information is confined to a sample from only one region of the country. Anthropometric data vary from state to state and often from district to district within a state. The figures from the Punjab are the highest for India; those from West Bengal and south Kerala are the lowest. Again, these data were gathered 17 years ago. And, in Japan, it has been found that over the decades after World War II, better nutrition and medicare have tended to increase the lengths of various body variables.

It should not be difficult to perceive why anthropometric data have a vital bearing on the design of furniture. In



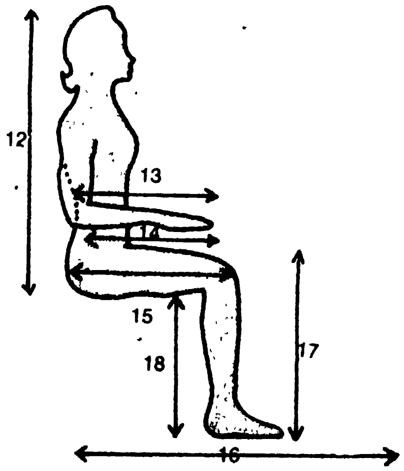
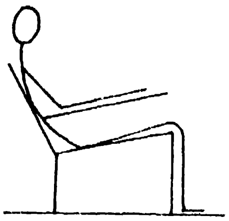


Table 1

Body variables	Measurement in cm
Standing	
1 Height (without footwear)	167.0
2 Crown to centre of eye	12.1
3 Shoulder joint to elbow joint	28.5
4 Elbow joint to wrist joint	24.4
5 Wrist joint to tip of middle finger	18.5
6 Shoulder joint to hip joint	45.7
7 Hip joint to knee joint	45.2
8 Knee joint to ankle joint	38.6
9 Ankle joint to floor	7.8
10 Ankle joint to tip of big toe	20.8
11 Length of sole	24.1
Sitting	
12 Crown to seat	86.3
13 Back to tip of middle finger	78.2
14 Rear elbow to tip of middle finger	43.9
15 Back to front of knee	56.6
16 Back to sole (leg extended)	100.8
17 Top of knee to floor	52.1
18 Inside of knee to floor	40.4

A chair with adjustable seat and back-rest height to suit any individual 1, 2 and 3 are screws for adjusting the back-rest height, back-rest inclination and chair seat height



Physical comfort ensures better mental performance Leaning on a properly shaped back-rest on a backward tilted seat is comfortable. Studies show that back-rest inclination (about 110-120° to the horizontal) and seat-surface backward inclination (about 14° to the horizontal) plus a lumbar (low back) support reduce intervertebral disc pressure That is why sofas which are meant to lounge in have sloping seats and backs The relaxation probably occurs because some of the body weight is shifted to the back A good back-rest should be slightly concave at the top and distinctly convex in the lumbar region

a sitting posture, the body variables "elbow joint to sole" would govern the height of a table; "inside of knee to floor" would determine the height for a chair; "back to front of knee" would influence the depth of the seat of a chair; and so on.

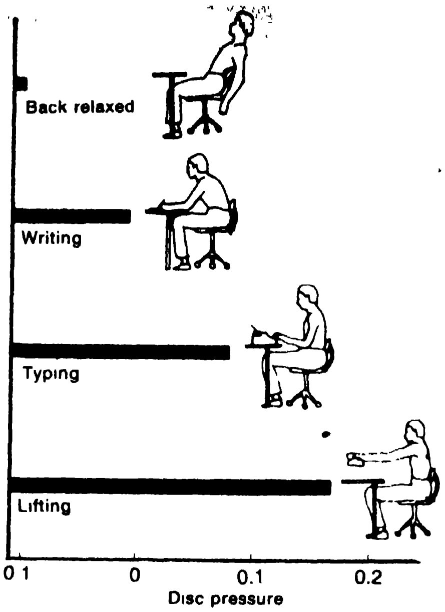
It is not that limitations of anthropometric data are only confined to variations in different parts of the country. Even if the data are compiled for a particular state, where variations between districts are not pronounced, for example Gujarat, the figures are merely the *averages*. Even with 'percentiles' incorporated, it does not meet individual requirements but represents the 'mean' for the population. Percentile is one of the variables which divides distribution of the variable into 100 groups having equal frequencies. Thus we can divide the height of a group of people from zero to 100. And suppose the chair is designed for those of anthropometric variations of 50 percentile a good number of people around this height can use the chair. However, the too tall or too short people will not be able to use the chair. Thus, in a large office, the majority of the furniture should be designed for the 'average', while a small number must cater for the people below the 25th percentile and above the 75th percentile. Outside this range mass production is not feasible.

However, furniture manufacturers in India use one standard scale; they do not cater for the variations in anthropometric data from region to region. For example, the height of the chair is taken as 41 cm (16½ inches). Almost any chair can be made adjustable with respect to height, but the increase in the cost of manufacture does not make it practicable.

The second factor which must be considered in the design of furniture is the 'physical load' imposed on the base. When a person sits on a chair he exerts a certain amount of force on it. The chair too exerts a reactionary force on the person. This contributes to the static physical load. One feels this load even while lying down, but then, while lying down, it is minimal because the load is distributed over a larger area of the body. Incidentally, it is this static load that causes sores in bed-ridden patients. It occurs when a force is applied by any limb without producing a corresponding movement.

A great deal of 'static' physical load is imposed on the lower positions of the buttocks and the thighs while sitting. They can result in restricted circulation of blood to the body's lower parts, giving rise to discomfort, temporary loss of sensation, cramps and other effects. How long then is a person going to use that furniture? And what degrees of minimum comfort should he expect for various durations of its use?

The visitor too needs leg-room under the table to avoid leaning forward too much. If the table is covered on three sides, it should have a desk overhang to provide leg-room



Disc pressure between lumbar vertebrae, L3 and L4 in different sitting postures Disc pressure zero is a relative value related to a reference trunk position

Disc pressure can be an index of the relaxation of the back muscles The figure shows the lowest disc pressure for the relaxed position Writing with hands on the table creates less pressure on the back than typing where the arms have no support Lifting a weight from the table causes highest disc pressure while sitting The disc pressure also varies with the angle of inclination of the back-rest. When the back-rest angle is increased, the disc pressure gradually falls

When a person is routinely exposed to long periods of static loads, chronic pains result. This is due to pathological changes in the muscle, tendons which bind the muscle to the bones, ligaments which connect two bones and the joint capsules. Over long periods of time, this may lead to permanent damage, due to wear of the capsules. And worn-out capsules result in diseases of the joints.

Bad sitting postures are often the cause for backaches. And the bad postures could be due to the ill-suited chair. Backaches occur when the discs between the vertebra of the backbone are worn out. It has been found that intradiscal pressure is higher while sitting than while standing. Bending forward increases the pressure. Now, the discs themselves do not have a good blood supply; they absorb nutrition through the liquids surrounding them. If subjected to high pressure, liquids tend to flow out of the discs. When the load is reduced there is an inflow of fluid into the discs. The fluctuations in load act as a pump.

Most people periodically change their sitting position. We lean back to relax. A well-designed back-rest is

Telephone operators have to lean forward most of the time A certain amount of swivel and an adjustable back-rest which fits snugly would help the operator to relax by leaning backwards

When work has to be done across a long table, as in the case of a sorter, a chair with castors will save him the trouble of getting up and moving about along the table or leaning forward too much

often helpful. Again the height of the back-rest depends on the nature of the work. For example, for relaxation an ideal chair is the one with a complete back-rest. For desk work, involving reading as well as writing, a back-rest covering two-thirds of the upper portion of the back is best. For those who have to continuously lean forward, like telephone operators and typists, there is no need to have a complete back-rest. They should, instead, be provided with a support for the top 20 cm of the shoulder region. The support should be curved to suit the contour of the back. For leaning back and scanning, a low back-rest fitting the lumbar region on a tiltable chair is best.

It is very difficult to get a back-rest to suit the vertical contour and covering the whole back. The lower portion is generally left open for ventilation, particularly in hot climates. However, a well-designed back-rest covering the whole back and with a well-designed lumbar support allows the user a good posture while leaning as well as reclining.

The size of the table is also dictated by the status of the user. It is not uncommon to find a managing director's table measuring 3 x 2 metres. It would be well-nigh impossible to shake hands with a visitor across this table. Yet, in the same organisation, the mailroom clerk would have a table 1 x 0.65 metres.

All tables, however, must have a height which allows for comfortable resting of the arms on its surface. This is governed by the vertical distance between the surface of the table and the height of the seat of the chair, and is fairly constant. The height of the chair, after all, has to conform to anthropometric data. And once the height has been determined after taking the body measurements, the length, width and accessories have to suit the individual's work-needs.

Ideally, the tabletop should be at elbow level. When the table is too high, the user tends to lift his shoulders to work and even to rest his elbows on it. This causes pain in the shoulders and neck. Very high arm-rests would also create the same problem.

Too low a table would not allow sufficient leg room. This would hamper movement Freedom of movement and change of posture are extremely essential to comfort.

In a study carried out in the UK it was found that the ideal study table height for general purposes was between 58 and 76 cm for women, the optimum being 68 cm. Indian women are much shorter. No such studies have been carried out in this country, but it would be interesting to find out how many of our women are sitting at tables higher than their comfortable 'reach'.

An inclined tabletop set at an angle of 30° to 35° makes it easier to write or draw.

What storage space a desk must contain? An executive's desk need not have a number of drawers. But a personal assistant's table must. This could be a table with drawers having provision for holding files vertically.

When a person has to receive visitors frequently, his table must have an 'overhang' of the surface at the visitor's end. This will ensure enough leg-room for the visitor. This is specially needed for desks which have three sides fully enclosed.

In the design of sofas for offices or homes, particular care must be exercised to ensure that the height is kept as low as possible to facilitate good 'lounging'.

While arm-rests are ergonomically desirable, it is generally a matter of fashion. The inclination of the seat, fitted downwards towards the rear, and the inclination of the back-rest, are important considerations that contribute to 'comfort'.

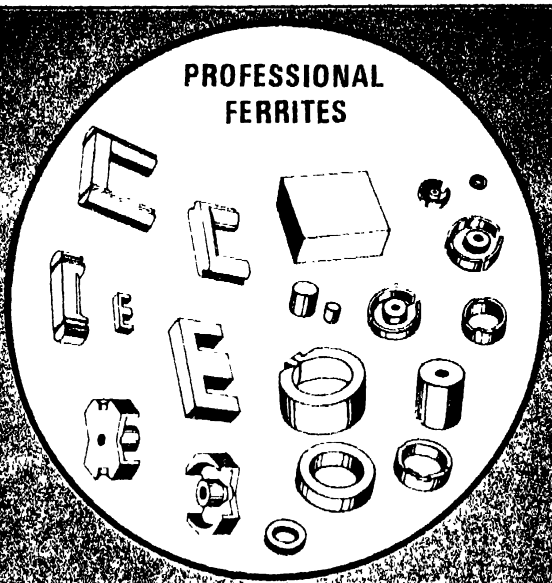
It was not till 1962 that the Association of British Furniture Manufacturers decided on the standard height of a chair, which prior to that varied from 50.5 to 40.5 cm. Imagine an average Indian sitting on a 50.5 cm high chair, with his legs dangling! He will develop numbness in his feet. The Indian manufacturers copy the dimensions from the west, little realising that while the average height of a westerner is about 176 cm, that of an Indian is much less. If so much could be done for simple chairs and tables, with an intelligent use of ergonomics, the potential for other furniture, fixtures and equipment can easily be visualised.

Brigadier Pennathur got his Ph D in Industrial Management from the University of Delhi He retired from the Indian Defence Services as the founder-director of the Defence Institute of Work Study His fields of specialisation include Production management, Industrial engineering, O & M, Industrial management, Materials management, Network analysis and Ergonomics He is currently coordinating the Commonwealth Research Programme on Standard Rate of Performance of Workers (physical loads only) and is also engaged in certain facets of ergonomic research based on the Indian socio-industrial environment

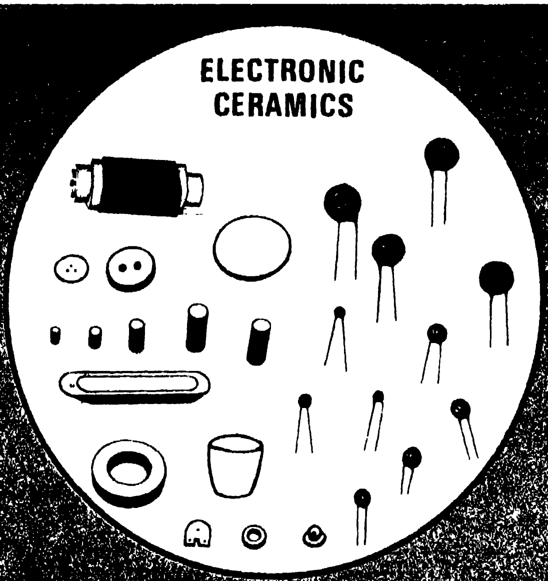
Answers to the Maths Olympiad

1 D, 2 D, 3 C, 4 D, 5 B, 6 D, 7 A, 8 C, 9 B, 10 D, 11 B, 12 C, 13 C, 14 C, 15 C, 16 A, 17 A, 18 C, 19 C, 20 B.

(After answering the questions try to prove the right answer. This is a much more difficult exercise. It naturally needs more time, but is well worth the effort.)



PROFESSIONAL FERRITES



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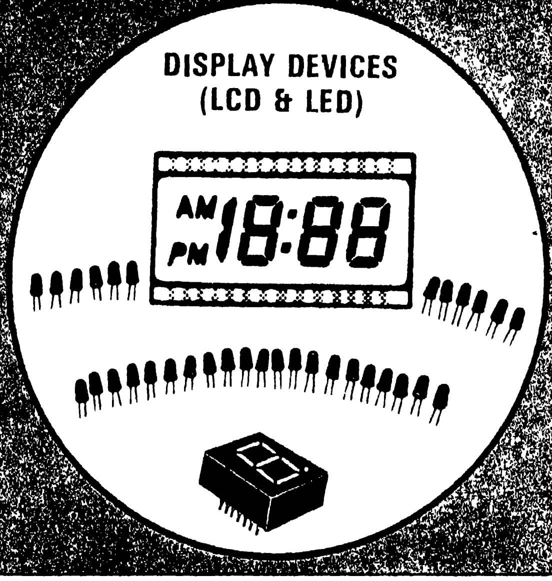

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The doctor as detective

Was it accident, suicide or murder? The testimony of the medical officer is important in every case of suspicious death. He may be presented with no more than a few bones, but may be called upon to identify the dead person, to pronounce where, when and by what means he died. The method he adopts to seek the answers is, essentially, the method all scientific investigations are based on. And in the answers lie the clue as to who the killer was. In this first article of a series are described the techniques which help to identify a dead body.

Pritam P. Phatnani

"Murder, though it has no tongue, will speak with most miraculous organs."
William Shakespeare

PEOPLE GENERALLY associate doctors with health and disease. Seldom do they realise what an important role the doctor as forensic pathologist can play in helping the police to solve a crime, especially involving murder.

Dead men always speak the truth, if you know how to listen to them and are able to understand their language. But it requires, in addition to a watchful eye and sensitive hands, specialised knowledge acquired through the study of forensic medicine. For, only a well-trained forensic pathologist can interpret the language of the dead.

There are seven "Ws" in this language of the dead. These are: *Who* is the dead man? *When*, *Where* and *Why* did he die? *What* did he die of? *Who* is the killer? And *Whether* it is murder, suicide or an accident? Forensic medicine is that branch of medicine which applies medical knowledge to the requirements of law or vice versa. It is for this reason that forensic pathologists are popularly referred to as medical detectives.

Unlike the police detectives and other operatives who have an elaborate apparatus at their command, the doctor has just the dead body, and its surroundings to rely upon. He has to uncover almost all the evidence from his find and the setting immediately around it on his own, although he may receive the close co-operation of the crime detection agencies.

Taking the seven Ws one by one, let us see how the doctor goes about his work on the postmortem table and in his own workshop, the department of forensic medicine (see box on p 64).

Who is the dead person? In criminal cases, it is important to identify the dead body because the victim's identity greatly increases the chances of arresting the murderer. One can trace the last movements of the deceased and locate his or her enemies or friends and find out who stood to gain from his or her death. It also helps to deduce the possible motive for the crime.

Identification of the dead is also important in settlement of important civil procedures like insurance claims, resolution of partnerships, administration of estates, etc which would otherwise have to await presumption of death, the period for which is seven years. In mass disasters, it helps in establishing the total number of the dead, in the settlement of compensations to the rightful claimants, facilitates the investigation of the accident, and helps in the prevention of accidents in future.

For proper disposal of the dead in accordance with their prescribed religious rites also, it is necessary to identify them so that the religious sentiments of their kith and kin are satisfied. Cases are on record at the Coroner's Court in Bombay, of a Hindu's body being claimed by a Muslim and a Muslim's body by a Christian, and so on. In some cases, the mistakes are realised in time, but in others—when a body that ought to have been buried has been cremated—it becomes quite difficult to pacify the wronged party. In cases of infanticide, identification can establish paternity.

How does the pathologist go about to identify a body?

Fingerprints, when available for comparison, are the most definite proof of an individual's identity. However, they may not always be available, or if available, there may be no record to match them with. In such cases one has to rely on other methods of establishing the identity of the body.

Identifying from the personal belongings is a common practice in mass disasters. On 12 February 1976. there was a flash fire in a Thane-bound local train near Matunga station, Bombay. Twenty-two persons were burnt alive, some of them charred beyond recognition. During the postmortem examination at the J.J. Hospital morgue, two bodies were identified by relatives because of the wrist watches, a third from the gold

Scene-of-crime precaution

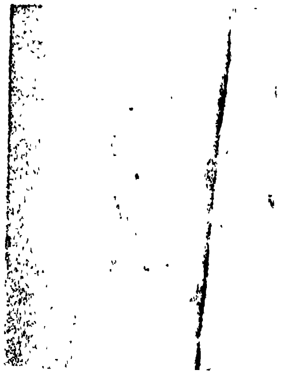
IT IS of the utmost importance that a dead body is not disturbed until the forensic pathologist reaches there and the neighbourhood is examined carefully for fingerprints, blood stains, bullet marks, etc. For, according to Prof. Glaister's Theory of Exchange (see SCIENCE TODAY, January 1973, p. 52) there is always an exchange of material between the criminal and the scene of crime.

The pathologist and the police officer should photograph the entire scene of crime from different angles and search for clues of any physical evidence of violence responsible for death, even if it is self-induced or suicide. The body should be photographed with and without the clothes. All the physical evidence present on the body should be collected and sealed properly for further examination. A careful examination of the body at the scene of the crime will prevent any distrotion of the biological changes like rigor mortis, postmortem lividity, etc (see SCIENCE TODAY, November 1974, p. 49). The exact position of the body, the position of any weapon found near the body and any notes like suicide-notes are taken note of. There may be marks of struggle on the body.

P.P.

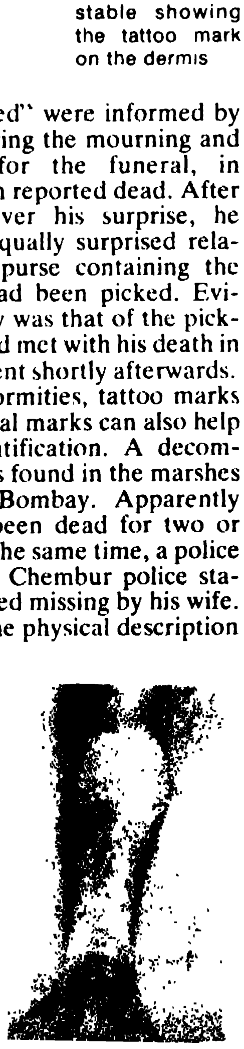
rings, and a fourth from the stainless steel waist-band. A few were identified from the designs on their partially burnt clothing. An interesting episode was that for one body there were two claimants, the attraction apparently being the compensation of Rs.50,000 offered by the Railway Ministry to the nearest relatives of the dead. One person, who claimed to be the brother of the deceased, produced a family photograph in which the deceased was wearing the same shirt which he was wearing at the time of the disaster. Also, both the brothers had a squint in the right eye. This claimant was given the body.

Sometimes, however, these personal belongings can be misleading. In one case, because of the purse and railway pass on a dead body found on the railway track in Bombay, relatives of the "deceased" were informed by the police. During the mourning and preparations for the funeral, in walked the man reported dead. After he had got over his surprise, he informed his equally surprised relatives that his purse containing the railway pass had been picked. Evidently the body was that of the pickpocket, who had met with his death in a railway accident shortly afterwards.



The forearm of the police constable showing the tattoo mark on the dermis

Physical deformities, tattoo marks and occupational marks can also help greatly in identification. A decomposed body was found in the marshes of Chembur, Bombay. Apparently the man had been dead for two or three days. At the same time, a police constable from Chembur police station was reported missing by his wife. According to the physical description given by her, his right forearm had the figure of crucified Christ tattooed on it. Strangely, the constable's colleagues had failed to notice this tattoo mark, probably owing to his dark skin. At the time of the postmortem examination, however, the superficial layer of the skin (epidermis) could be peeled off easily, owing to decomposition, revealing the tattoo marks. But his wife and colleagues were still unconvinced: the facial features were beyond recognition, and, besides, couldn't two people have identical tattoo marks? Closer examination revealed that the skin over the calf muscles of both legs was of a lighter shade, suggesting that the deceased was in the habit of wearing the strap stockings (putties) which is part of the uniform of police constables in Bombay. After that, his wife and colleagues had no further hesitation in claiming the body.



The same constable's calf muscles reveal lighter shade of skin due to the use of strap stockings

Identification can also be established from the blood group and the enzymes present in the blood. An X-ray examination of the body will reveal any skeletal deformity or old injury. These can be compared with X-rays taken when the person was alive. Microscopic examination of tissues will determine the presence or absence of any disease.

From the skeletal remains, one can determine the age, sex and physical stature of the individual. If the teeth in the jaws are intact, then dentists' records can be of tremendous value in identification. If only the skull is available, one can establish the identity of the face by means of the superimposition technique, first used by Drs. Brash and Glaister in the famous Ruxton case.

Superimposition technique for identification. Life size photographs of the skull and the deceased are superimposed keeping dental patterns as focal points

The latest method in vogue is the reconstruction of the face on the skull using silly putty (Plasticine). Following the method of Krogmen, S. Chaudhari and J.B. Mukerjee in India have determined the average normal thickness of skin over various bony prominences like the chin, cheekbones, forehead, etc. There are fifteen such points on the skull. Thus, after plotting these points with Plasticine of appropriate thickness, and interconnecting them with Plasticine strips to obtain a meshwork pattern, this meshwork can be filled with the appropriate gradient of Plasticine to get a broad contour of the face. The finer details regarding the shape of

Forensic pathologist at work

THE PRELIMINARY examination of the dead body is done in the postmortem room, the most important section of the forensic medicine department. It is here that the body parts and their contents are collected, preserved and forwarded for chemical analysis to the forensic science laboratory, which is quite independent of the forensic medicine department. However, when it is not possible to thus establish the cause of death, further examination is done in the forensic pathology laboratory, a part of the Forensic medicine department where the internal tissues are examined microscopically. Some of the instruments used in the preparation and examination of slides are microtome, histokint, possibly a frozen section unit and a microscope.

Another section of the laboratory consists of a photographic department for taking pictures of the deceased and processing them. These pictures provide an essential record of the nature and extent of the injuries, which suggest the manner in which death could have been caused. Colour photography helps tremendously in such cases because it adds depth.

The forensic pathological laboratory should also have serological unit.

Another section of the forensic pathology laboratory is the radiological unit for taking X-ray photos of the dead body. Radiological examination helps in establishing the age of the individual and also helps in investigating cases of death due to firearm injuries and in detecting any skeletal injuries or deformities.

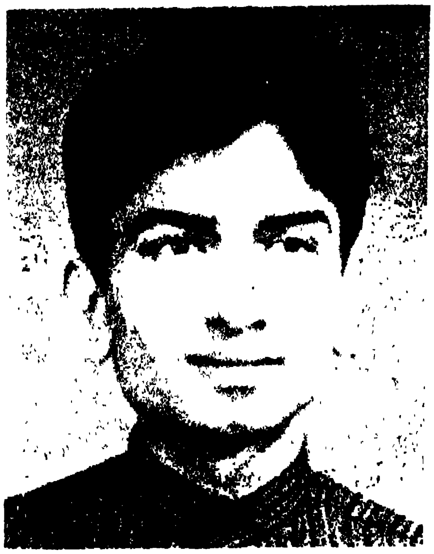
Another important section of the department is the clinical Forsenic Medicine section where the living victims of sexual and physical assaults, and cases of offences pertaining to prohibition are examined.

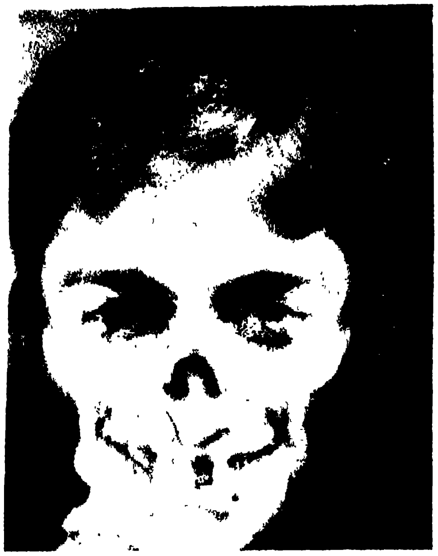
P P.

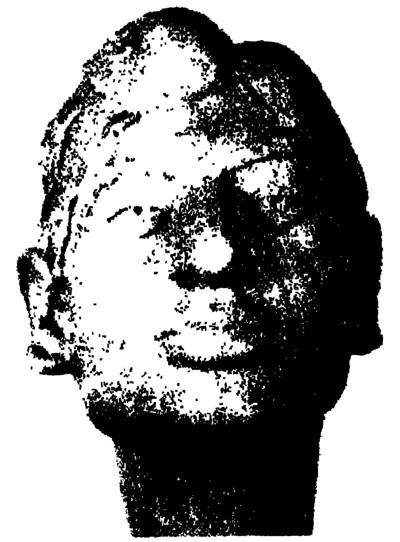
the nose, lips, ear-lobes, etc can then be fed to the medical sculptor to prepare the final bust and show it to the relatives or compare it with the available photographs to obtain the final identification.

At no stage of the process of reconstruction does the sculptor have access to a photograph of the deceased.

The superimposition and reconstruction technique was successfully employed in a case in Bombay. A skeletonised dead body was recovered, from a septic tank near a school at Goregaon, a suburb of Bombay. The skull had separated from the body. The skeleton was macerated to separate the bones. There was no difficulty in establishing the age of the individual and his height. Knife cuts on the vertebrae of the neck, shoulder blades and ribs suggested that he had been stabbed to death. The teeth on the lower jaw, barring one, were intact. They were set in a peculiar pattern. Of the few upper jaw teeth available, one—the upper right incisor—had a peculiar notch.







The average thickness of the skin over fifteen points of the bony prominences of the skull is known. Using this data, the face is 'filled in', beginning by marking the skull with Plasticine buds of appropriate thickness. Photographs show face reconstructed from a skull and also the actual photograph of the person

Lists of people missing from that area were checked by the police, and their photographs obtained wherever possible. The suspicion arose in the case of an individual who was a photographer himself and had taken his own pictures with a timer camera. One such picture showed him in a smiling pose where his dental pattern was clearly visible. On comparing it with the skull it was found that the dental patterns of the photograph and the skull were identical. The superimposition technique confirmed the identity further, when the skull and face were aligned, keeping the notched upper tooth as the focal point. It was then decided to perform the reconstruction of the face, and the result was remarkable. This is the first and the only case reported in India so far where such an attempt was successfully made to identify an individual.

The job of identification is not necessarily simplified by close relatives. They often make assertions which prove to be false. Such errors are even possible in the case of living persons who may be falsely identified, mostly by sight, to the embarrassment of both parties. But in the case of murdered persons, it can seriously hamper the detection of the crime.

There are relatives and friends who presume, when a man is missing, that he is dead. They are so grief-stricken that, without waiting long enough and without proper scrutiny, they will go ahead to identify any dead body which has the slightest resemblance to their near and dear ones. On the other hand, there are people who will deny that the dead one is their kith and kin in spite of all the positive points of identification. They are so overwhelmed by the loss that they tend to reject the fact of death and, for that reason, the identification of the dead body.

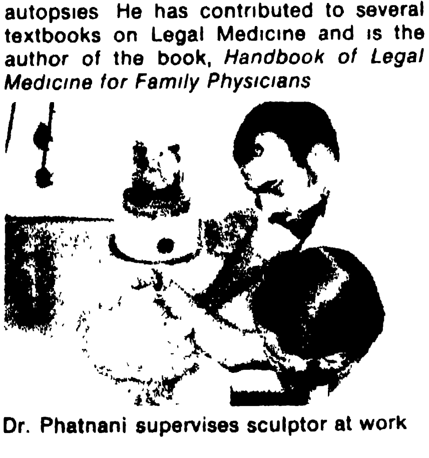
While most of these cases of 'misidentification' are due to genuine errors, occasionally the motive can be dishonest.

One possible way to ensure positive identification is to prevent a visitor wanting to identify the dead body at the morgue or at the hospital from being shown the body until the doctor or the coroner is satisfied about his bona fides. Prior to viewing the body, the potential identifier should be asked to describe or list more than one reliable, specific and permanent identification mark like old scars, tattoos, moles, etc on the dead body. He should be questioned about the movements of the dead person before death and about his purpose in coming forward to identify the deceased. It would be wise to question the claimant about his own identification and whether he can establish the same with documentary evidence.

This method may sound absurd and lengthy, even cruel, but it reduces the chances of mistakes tremendously. What is, however, most important is that the body in question must always be photographed, kept clean and, before it is allowed to be identified, all possible and necessary methods of identification must have been used by the pathologists. This would help in a quicker solution of the crime.

At the scene of any mass disaster, people should be prevented from unduly handling the bodies and care should be taken to keep their personal belongings on the bodies. They should be removed to the morgue neatly tied in bed sheets.

Dr Phatnani, presently head of the medical education department of a well-known pharmaceutical concern, was a coroner's surgeon from 1972 to 1975 and a lecturer in Forensic Medicine at the Grant Medical College, Bombay Having specialised in Forensic Pathology, he has performed over 6000 autopsies He has contributed to several textbooks on Legal Medicine and is the author of the book, *Handbook of Legal Medicine for Family Physicians*



Dr. Phatnani supervises sculptor at work

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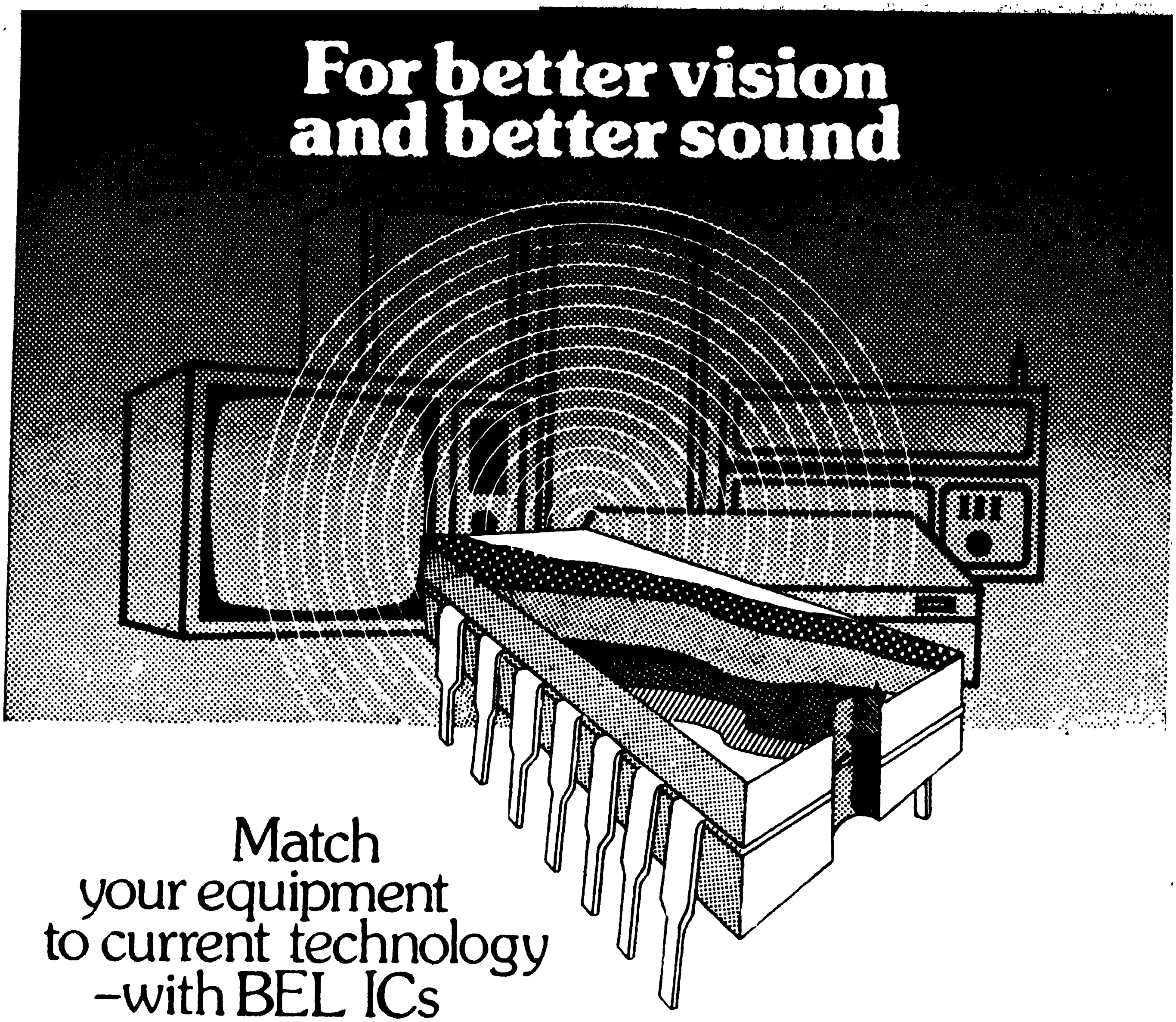

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... whether fish really 'drink' water?

ALTHOUGH "he drinks like a fish" is a common expression today, it is not a very accurate one when applied to fish.

Water fills a fish's mouth as soon as it is open, but, interestingly, fresh water fish never drink a drop of it. On the other hand, most marine (salt water) fish, continuously 'drink' water. (The term 'drink' is not necessarily used here in the conventional sense of voluntarily consuming water through the mouth.)

Whether a fish has to 'drink' water or not depends on the physical phenomenon of osmosis. Osmosis occurs when two solutions of different concentrations—one strong and the other weak, depending on the quantity of salts dissolved in the solvent—are separated by a semipermeable membrane. There is a gradual flow of the weaker solution into the stronger. Obviously, the higher the concentration of the salts in the solution, the greater will be the osmotic pressure (OP) and therefore more intense will be the inflow. So, the manner in which a fish imbibes water will depend on the concentration of the salts dissolved in the water in which the fish lives, and on the concentration of its body fluids.

That explains why fresh water fishes do not have to drink any water. Since fresh water contains very little of dissolved salts, the osmotic pressure is practically nil. On the other hand, the blood and tissue fluids inside the fish exhibit a higher osmotic pressure (some six to 10 atmospheres) because of the dissolved salts and body proteins. This causes the water of the river or lake to seep into their bodies, it being a much weaker solution. With so much water being imbibed all the time, one problem a fresh water fish should encounter would be to keep itself from brusting. This problem is handled by a very efficient set of kidneys.

In marine fish, the problem is generally reversed. There are two types of marine fishes, the bony *(Osteichthyes)* and the cartilaginous *(Chondrichthyes)*. The blood in the bony marine fish contains a lower concentration of salts (OP, 10 to 15 atm) than the surrounding sea water (OP, about 32 atm). So it's osmosis again. But this time it is *exosmosis*, causing water to continuously seep *out* from their bodies

Had it not been for nature's built-in processes, the sea, paradoxically, could have dried up the fish that swim in it. Because the problem for the marine fish is to replace the water sucked out by the sea, the fish is able to keep itself from getting dehydrated by continuously 'drinking'.

The marine cartiaginous fish, the sharks and the rays, for instance—which come below the bony fish on the evolutionary scale have adapted themselves to salt water in a different manner. They had to, because the osmotic pressure of their blood is even higher than that of sea water. This is on account of the high levels of urea in their blood, which they do not expel like other animals. So, like the fresh water fish, the cartilaginous fish of the sea, too, have to take in and then expel water continuously from their bodies.

It is believed that the phenomenon of thirst and drinking arose some time in the course of the evolution of the vertebrates during their attempts to adaptation to life on land. The first vertebrates to live on land were perhaps the amphibians. Frogs and toads also do not drink through the mouth when thirsty, they too imbibe water through the skin. Maybe later, as evolution progressed, the skin in the higher animals became more and more protective in order to conserve the body's moisture reserves. And the thirst drive that followed must have led to the channelling of water through the mouth.

B. S. MAHAJAN

Dr. (Mrs.) Mahajan is on the editorial staff of SCIENCE TODAY.

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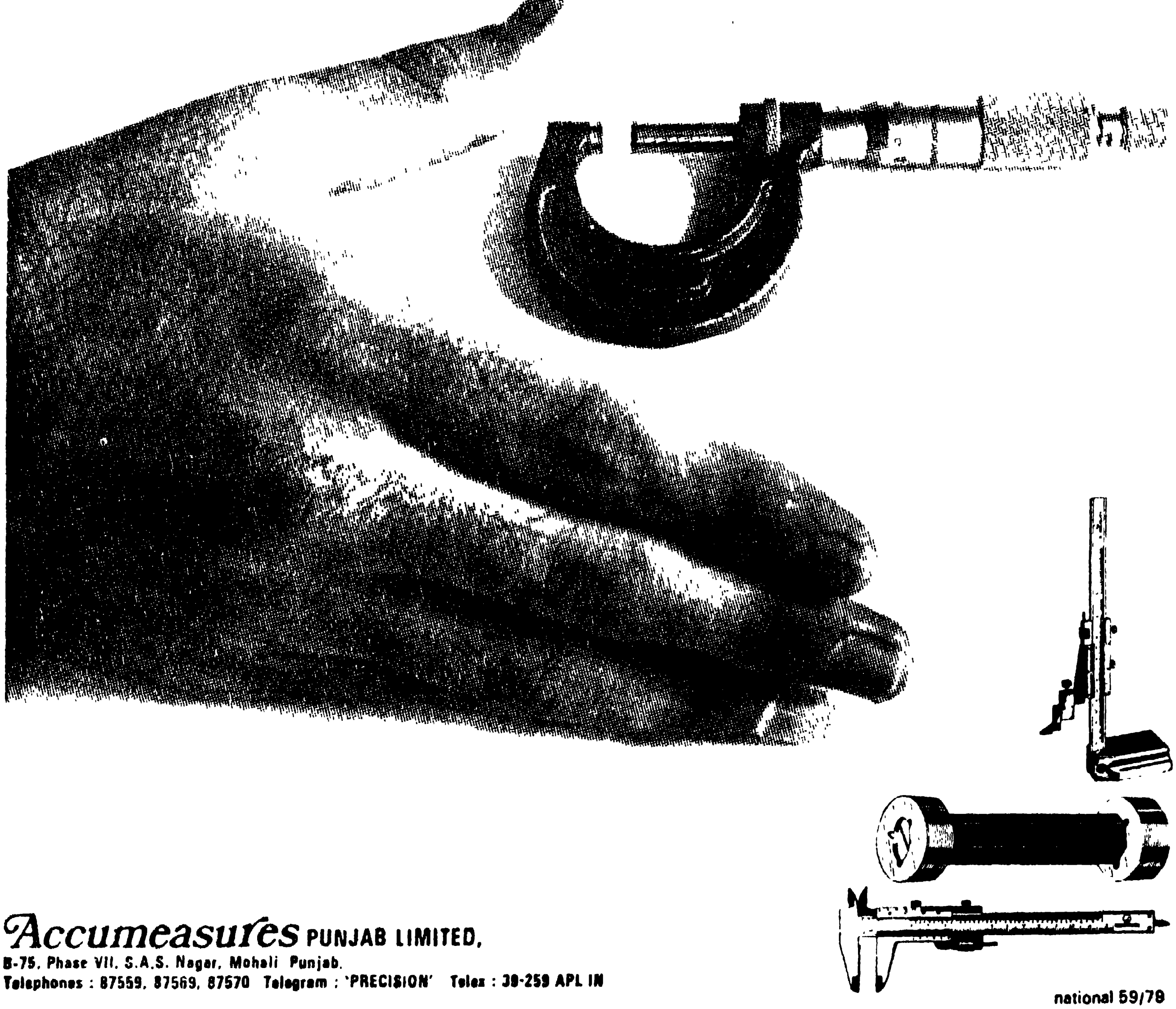

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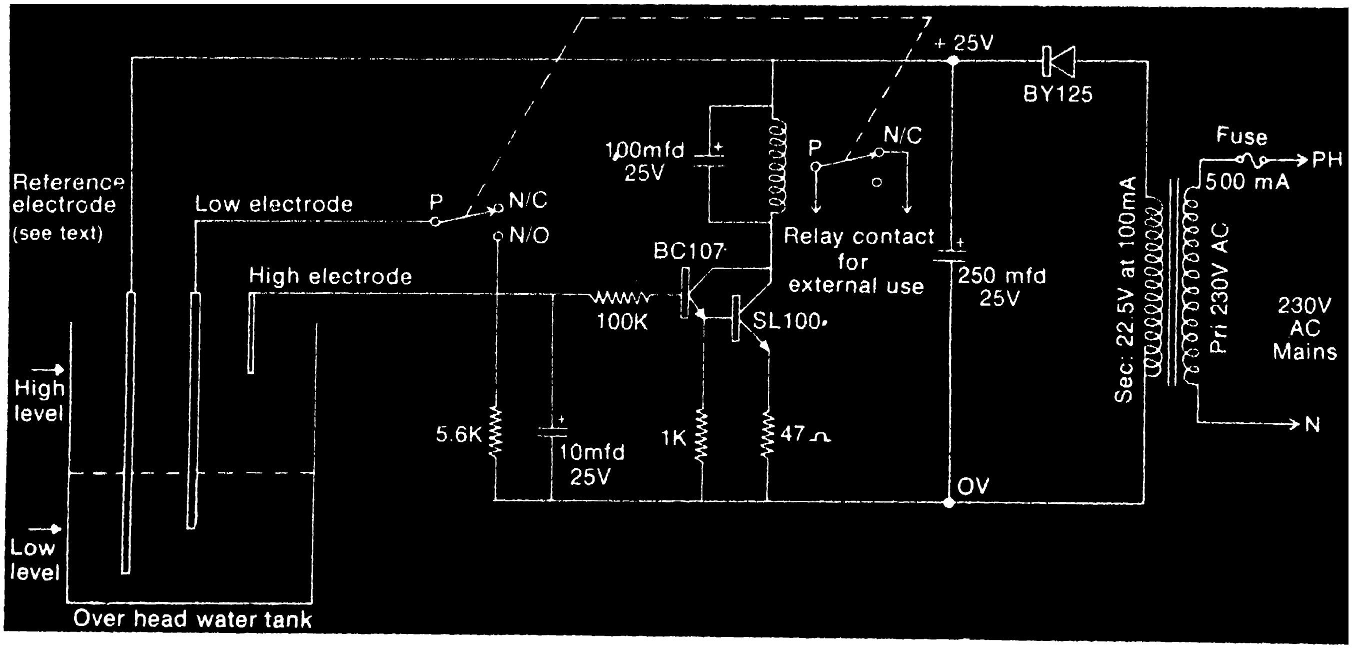
Solid-state water level switch



This is a fully solid-state water level switch using two transistors and a few other components. This switch can also be used for automatically controlling pumps that feed overhead water storage tanks. When the water level in the tank falls below the preset minimum level, this unit switches on the pump. When the level reaches the pre-set maximum level, the pump is automatically switched off. Thus, the water level in the tank is automatically maintained between the two pre-set levels.

Both the minimum and maximum preset levels of water in the tank are sensed by two electrodes, "high" and "low", mounted from the top of the tank as shown in the diagram. These electrodes, along with the third electrode, called reference electrode, which goes almost to the bottom of the tank, provides the necessary current path through water. Though water is not a good conductor of electricity, the salt and minerals contained in minute quantities in tap water make it slightly conductive. The electronic circuit of the unit is such that any conductivity in the water is sufficient to operate the relay.

The reference electrode is connected to the 25 V connection of the power supply. The high electrode is connected to the common point of the 5.6 K and 100 K resistors. The other end of the 100 K resistor is connected to the base of transistor BC 107, that is, input connection of the common collector compound connection of two transistors driving the electromagnetic relay. This arrangement of two transistors is also called Darlington pair. The emitter terminal of transistor BC 107 is connected to the base of the transistor SL 100. The collectors of both transistors share a common relay load. The current gain of such a circuit is the product of the individual gains. The input impedance is much higher than that of the single transistor stage.

When the level of water in the tank rises sufficiently and touches the bottom tip of the high electrode, the minute current between the reference and the high electrode develops a sufficient voltage across the 5.6 K resistor to drive the Darlington pair in conduction, and the relay energises. As a normally closed contact is used to operate the electrical starter operating the pump, the relay, when energized, switches off the pump. One additional normally open relay contact is connected between the high and low electrodes. Thus, when the relay energizes, the contact gets closed. The net effect of this virtually extends the high electrode from high to low level. The relay remains energized and the pump remains off till the water level falls below the "low" level. The relay de-energizes and remains de-energized (which operates the pump) till the level once again touches the "high" electrode.

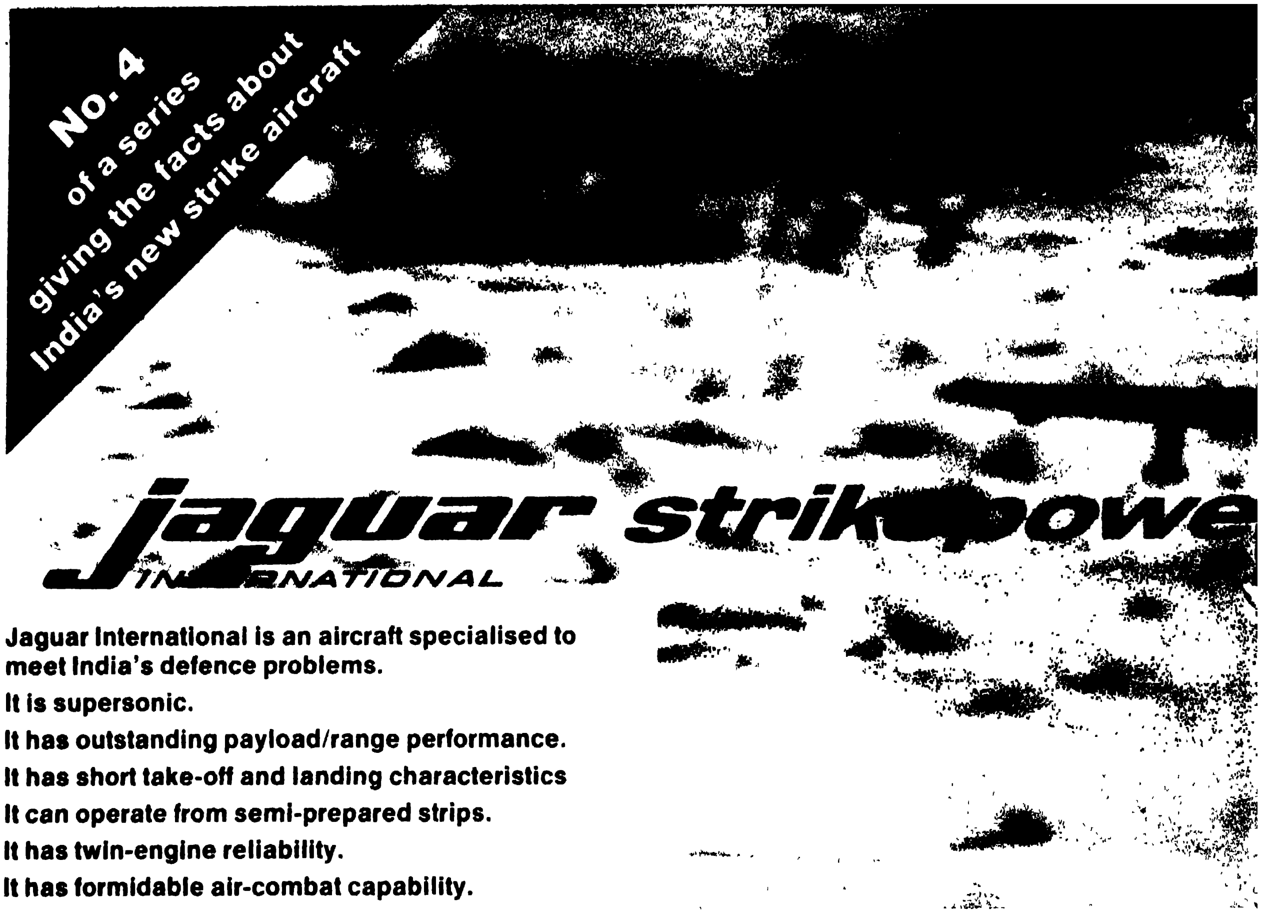
Three metallic rods of sufficient length can serve as electrodes. If the storage tank is metallic, the reference electrode can be eliminated and the connection can be terminated to the metallic body of the tank. For reliable operation, all the three electrode connections should be highly insulated. The resistance offered between any two electrodes when the water level is not touching the high and low electrodes, should be at least 1 megaohm.

You will need:

Transistors: BC107 - 1 No.; SL100 - 1 No.
Rectifier diode: BY125 or BY126 - 1 No.
Capacitors (electrolytic): 250 mfd - 25V - 1 No.; 100 mfd - 25V - 1 No.; 10 mfd - 25V - 1 No.
Resistors (all ½ watt) 100K - 1 No.; 5.6K 1 No.; 1K - 1 No.; 47 ohms - 1 No.
Approximate cost of the above electronic components in the Bombay market is Rs.22.
Relay: 24V DC with coil resistance more than 500 ohms with at least two changeover contacts - 1 No.
Transformer: Primary 230V AC; Secondary 22.5V at 100mA - 1 No.
Misc: Group board or vero board, suitable enclosure, fuse 500 mA with holder, solder, wires, screws, metal rods as level sensing electrodes, etc.

ANIL V. BORKAR

"He writes my papers, so that I can concentrate on my research."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With its combination of supersonic performance, exceptional payload/range capability and outstanding airfield performance, Jaguar has set new standards for economical strikepower when operating in support of ground forces in fast-changing battle environments. In service with the Royal Air Force, L'Armée de l'Air, and two other air forces, Jaguar has demonstrated its ability to:

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Jaguar can operate from short runways of low bearing-strength, with the optimum warload/range mix to suit a wide permutation of tactical requirements. Mission profiles can also be suited to specific targets and the strength and composition of the defences. At altitude, Jaguar International has a speed capability in excess of Mach 1.5 and it is designed for very high speeds at low level. Advanced aerodynamic design ensures low gust-response, enabling defences to be penetrated at transonic speeds and at altitudes of 80 metres and less.

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Internal fuel tankage provides a radius of action at full load of some 350 statute miles on lo-lo-lo tactical missions and over 500 statute miles on hi-lo-hi missions. External tankage can be used to increase these ranges, and Jaguar International is capable of a ferry range of well over 2,000 statute miles.

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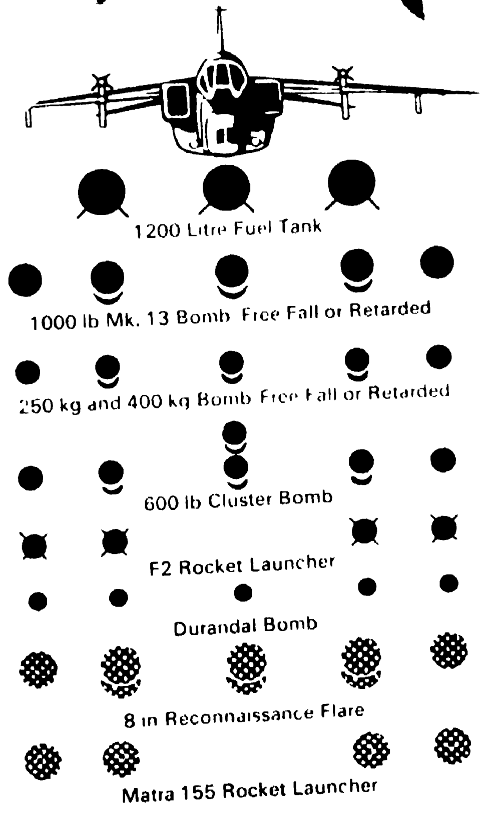
With Jaguar operating from forward airstrips, tactical air commanders can mount interdiction and ground support operations over a wide area, extending beyond the immediate combat zone to targets some distance behind the battle line.

Nav/attack system.
Jaguar is compatible with nav/attack systems ranging from the simplest to the most sophisticated standards. The RAF system, for example, is among the most comprehensive yet applied to a close-support aircraft. At its heart is a navigation and weapon-aiming digital computer, with outputs to a head-up display and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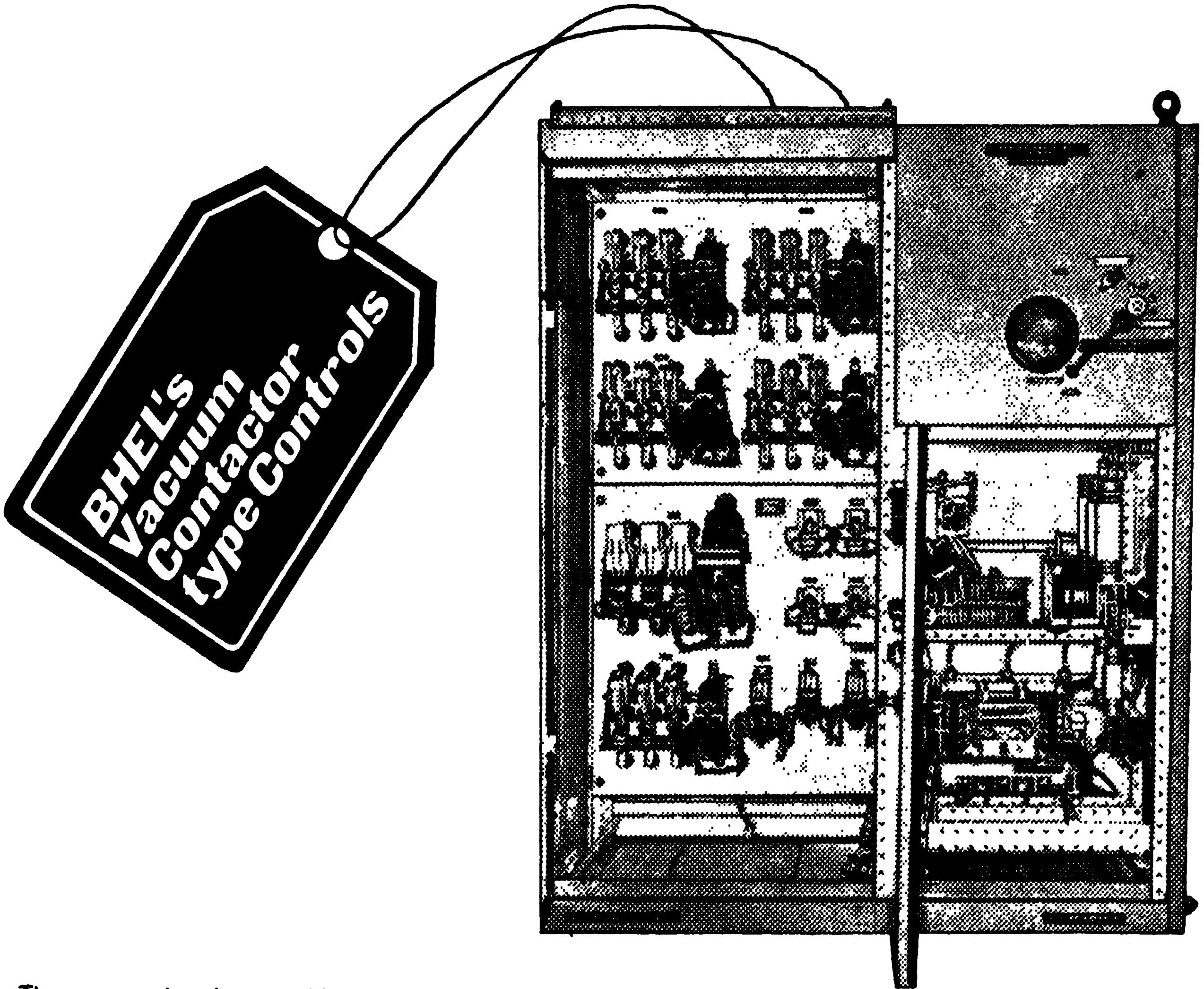

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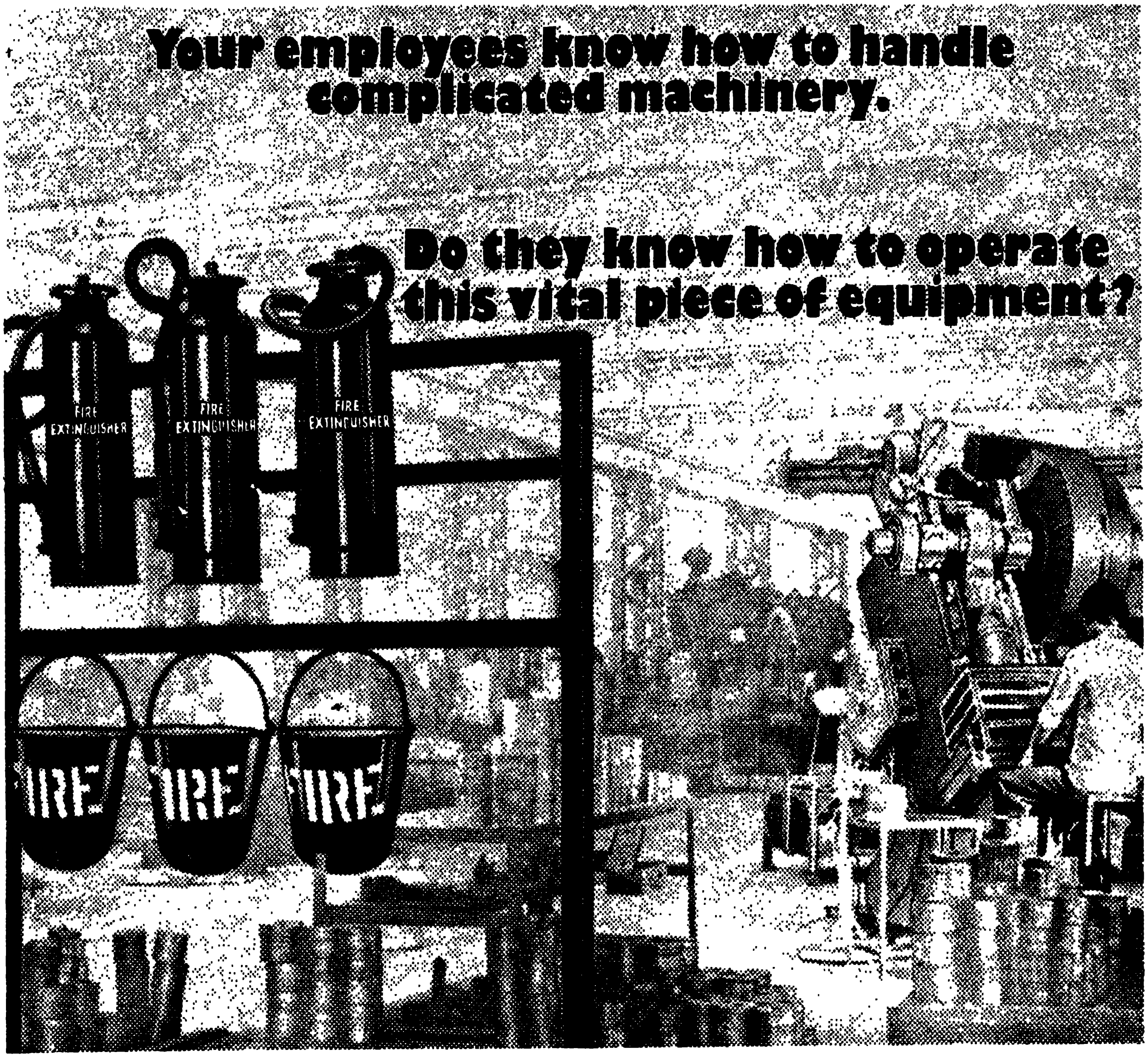

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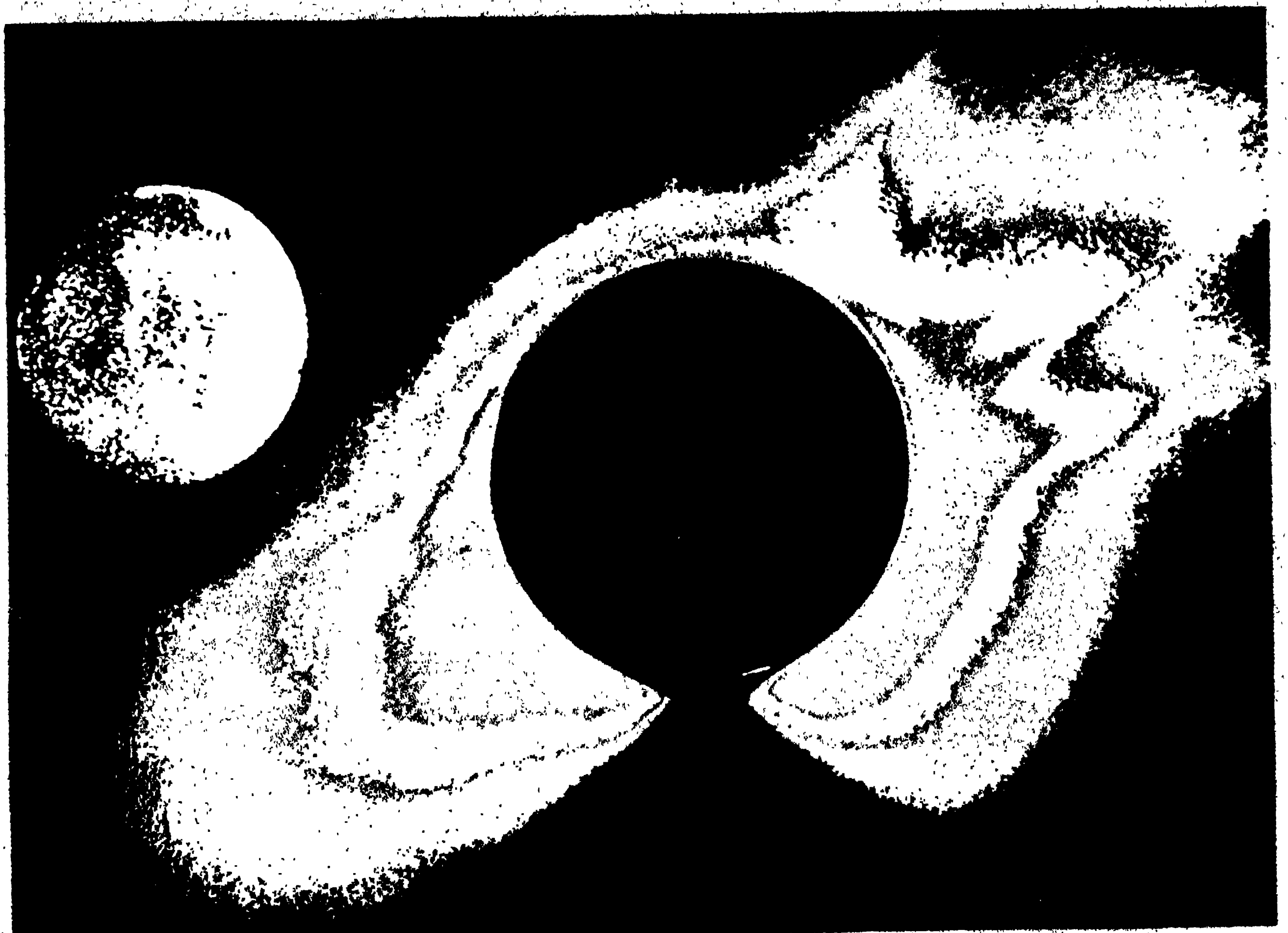

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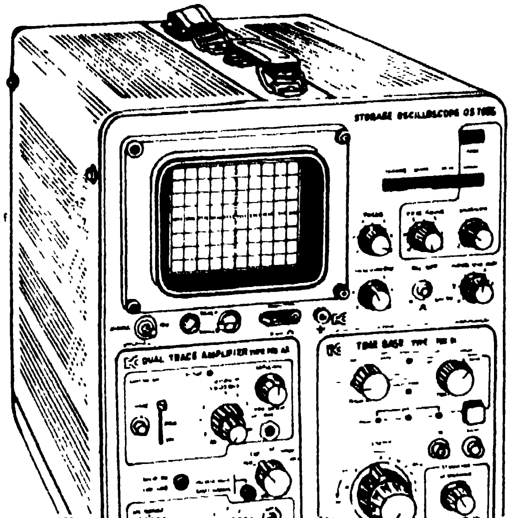

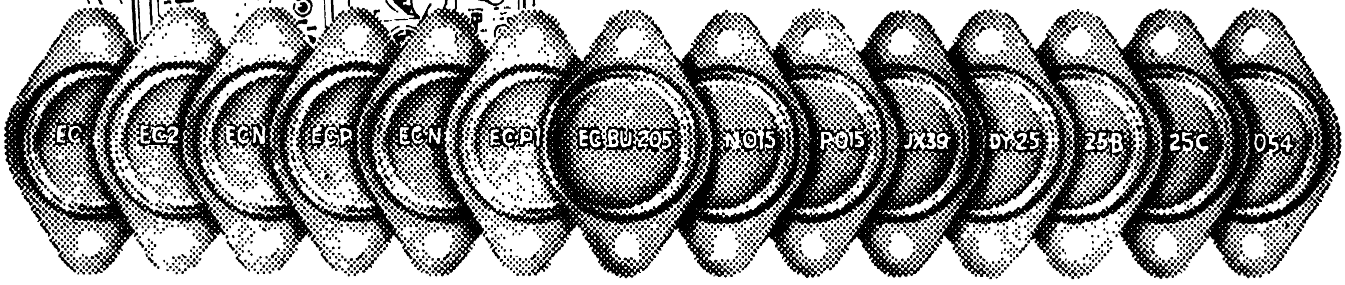

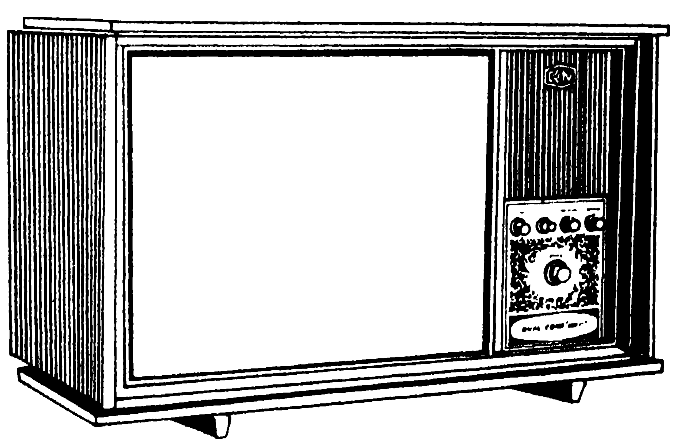

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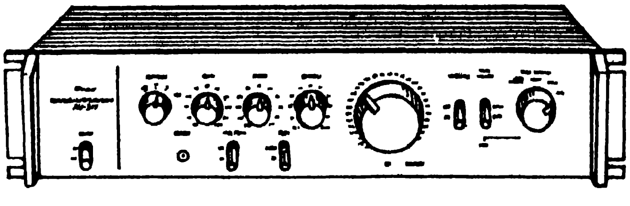

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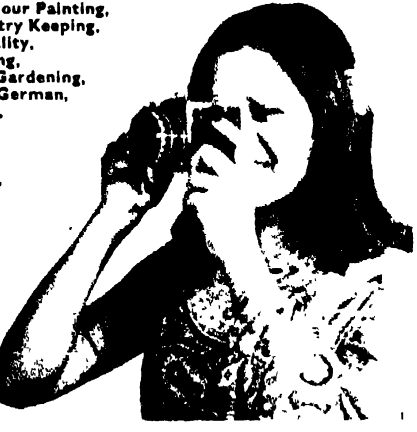

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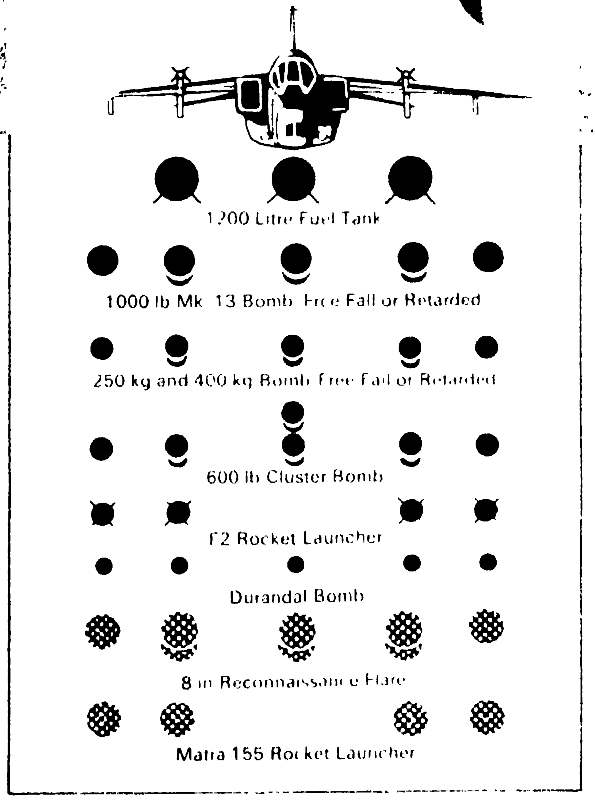
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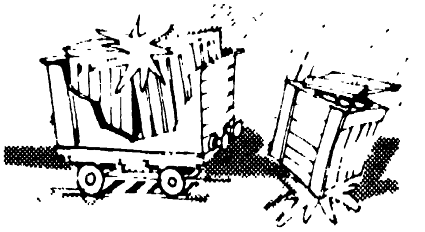
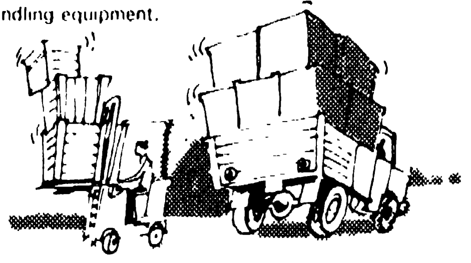
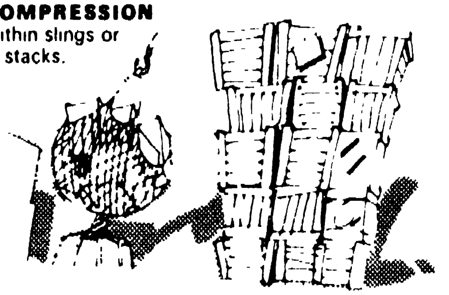


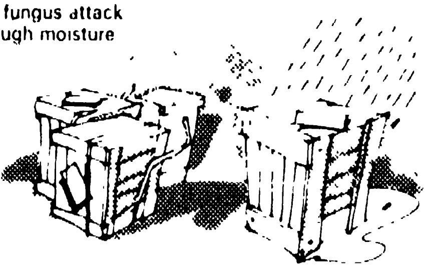
VIBRATIONS from vehicles and handling equipment.



COMPRESSION within slings or in stacks.



CORROSION and fungus attack through moisture



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Some basic loss prevention measures

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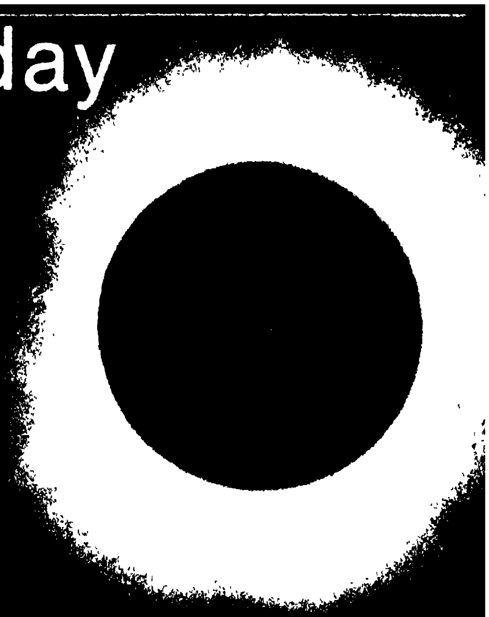

Never, never look at the partially eclipsed sun!

19 Sugar, the wonder molecule
Shiv Pillai, A Surolia and B.K. Bachhawat
Sugar associated with the membrane system is the new research frontier in cell biology

58 Clues to the time factor
Pritam Phatnani
Second in the series on the doctor as a detective

60 The method of science - 2
How does a scientist formulate, and then verify, his hypothesis?

69 Of fatigue and productivity
Krish Pennathur
A few simple methods to raise the efficiency of a worker

31-54 This solar eclipse is total
Why are astronomers from all over the world trooping in to watch India's first total solar eclipse of this century?

31 When the sun goes out
M.K.V. Bappu

35 Eclipses in mythology
Maithili Rao

36 How well do we know our sun?
S.M. Chitre

41 The solar corona
Arvind Bhatnagar

43 An eclipse watcher's guide
A. Bhatnagar, N.C. Rana and Jyoti Nevatia

47 Shoot the eclipse!
J. Mistry

50 The eclipse families
N.C. Rana

51 Effects on the earth's atmosphere
A.P. Mitra

---

7 Letters
8 Viewpoints
11 View from New Delhi
13 Blurs and Bright Spots
15 Science Shapes Life
27 Round-up of Research
29 This World of Science!
29 In Lighter Moments
55 Ideas and Inventions
57 Books
63 If...
63 Brain Teasers
65 The Bombay Mathematical Olympiad
67 Tell us...
73 You Too Can Do It
75 Awards and Appointments

---

8 A facade to perpetuate the old health system?
63 If there was no magnetism on earth

---

11 Milk schemes turning sour
73 IC tuned whistle switch

Cover: A simulated total solar eclipse: The new moon (tinted yellow here) is moving towards the corona. This was a black-and-white photograph taken by a coronagraph on Skylab and specially processed
Design: Feroze Chandra

Editor:
Surendr Jha

Single copy Rs. 2
Subscription: 1 year: Rs. 20
2 years: Rs. 39. 3 years: Rs. 58.

Editorial queries are to be addressed to the Editor, SCIENCE TODAY, Times of India Building, Dr. D.N. Road, Bombay 400001. Unsolicited articles must carry adequate return postage.

Subscription queries and payments should be addressed to the Circulation Manager, SCIENCE TODAY, Times of India Building, Dr D.N. Road, Bombay 400001.

Printed and published for the proprietors, Bennett, Coleman & Co., Ltd., by T P. Pithavala at Usha Offset Printers Pvt Ltd., 125 Govt. Industrial Estate, Kandivli, Bombay 400 067. General Manager: Dr. Ram S Tarneja. Branches: 7 Bahadurshah Zafar Marg, New Delhi 110 002; 139, Ashram Road, Ahmedabad 380 009; 105/7A S N Banerjee Road, Calcutta 700 014. Offices at: 13/1, Government Place East, Calcutta 700 069; 63 Montieth Road, Egmore, Madras 600 008; 407/1, Tirath Bhavan, Quarter-gate, Pune 411 002; 26, Station Approach, Sudbury, Wembley, Middlesex, London, U.K. London Tel. 01-903-9696

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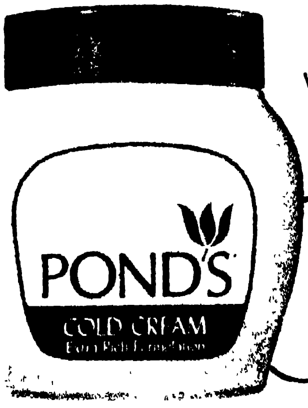

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ONLY A TRADITION?

Dr Jayaraman's concluding statement (View from New Delhi, December 1979) that the "All-India Institute of Medical Sciences (AIIMS) will continue to be plagued by problems as long as Dr. L.P. Aggarwal is unable to carry his faculty with him" is amusing. Pray, tell me who has been able to carry his colleagues with him in the type of democracy we have had during the last 30 months or so? Could even Prime Ministers Desai and Charan Singh do that?

All this is symptomatic of destruction, be it an organism or an institution. The situation at the AIIMS is only a reflection of our national leadership which is characterised by a lack of discipline, lust for power and each ambitious person trying to become an authority unto himself. Surely the hands of a socially conscious person like Dr. L P. Aggarwal needs to be strengthened to make AIIMS more meaningful to the common man

R L. Vishnu
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New Delhi 110 022

CYCLONES ON THE WEST COAST

Looking back on the near-panic created recently in Bombay with all those intensive warnings and alerts over a threatening cylonic storm, one wonders if we are not overrating the destructiveness of storms on the west coast.

Why have such storms on the *east* coast been real killers, many of them having taken thousands of lives?

Cyclones in general move east to west. The ones that hit the east coast have therefore had a long 'sea travel' across the Bay of Bengal. Cyclones hitting the west coast, on the other hand, are those which, emerging across the land into the Arabian Sea, have 'recurved' (turned back), with a consequently shorter 'sea travel'.

What is of greater importance is that, unlike the western coastline, the eastern coastline has just the right slope and orientation (with respect to the storm track) to raise heavy storm surges. And it is these storm surges that account for much of the calamity. The point is that the west coast cyclone is hardly 'in the same league' as its east coast counterpart

With the terrific holocaust of the Andhra cyclones fresh in our minds, it was perhaps natural for the authorities in Bombay to overreact But the basic difference in the destructiveness of storms on our west and east coasts must be kept in mind.

Although panic needs to be avoided, the authorities should prevent fishermen, by force if necessary, from venturing out to the sea when there is the likelihood of a storm

J.M. Korkhao
23, Almeida Road
Bombay 400 050

SEEING MORE THAN DOUBLE

In Celestial twins—or a case of seeing double" (Round-up of Research, November 1979) Prof. Apparao explains the sighting of two spectrally near-identical quasars, very close to each other, by saying that a black hole is present between the solar system and the quasar The black hole acts as a gravitational lens and makes us see two similar objects close to each other.

However, if such a 'lens' was in the place suggested, we would not see just two images but a ring of light with the black hole in the middle—making it doughnut-like in appearance.

Arun Murari
3/75 Marris Road
Aligarh 202 001

Prof. Apparao writes: Mr. Murari is correct. The location of a black hole exactly on the line of sight will produce a symmetrical image. The diagram given in the note is necessarily oversimplified Gravitational lenses produce multiple, complicated and extended images, depending on the location of the object and the observer with respect to the 'lens' Further reference may be obtained from *Nature* **282** 561 and **234** 199

COSMOLOGISTS' PHRASES

Mr K K Thickedath (Letters, November 1979) objects to the cosmologists' using such terms as "origin of the universe" and "moment of creation" These phrases, whatever else they may suggest, have more than ornamental value and embody concepts which are inescapable in the light of present knowledge

The phrases do not imply the presence of a creator external to the physical world If they happen to be rather colourful or vivid, that is only a thing to be happy about Isn't there enough dullness in this world of the routine?

Ajit Kembhavi
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NOT FAIR

In his review (Books, November 1979) Dr P Kumaraswamy states that "with laymen holding important administrative positions, conceptual planning meets with problems These generalists-cum-administrators advise politicians on technical matters and holding great financial powers, they even dominate over technical experts. "

Dr. Kumaraswamy should surely be aware that the Central Department of Irrigation is headed by an eminent engineer. The Ministry of Agriculture and Irrigation itself is now headed by an eminent agricultural scientist. Even at lower levels, important positions in this Ministry are held by engineers and other technical officers. This position obtains in a number of states also. Even where IAS officers are heading departments connected with water resources, both at the Centre and in all the states, the relevant rules and procedures give the right to the head of the department (who is invariably an engineer) to state his point of view before the minister, in case he feels that the secretary's advice is contrary to his own technical opinion Indeed I cannot think of any layman administrator presuming to advise on technical matters ignoring the views of technical experts.

A U. Sarma
C-II/46, Tilak Marg
New Delhi 110 001

Mr Kumaraswamy replies: The Department of Irrigation at the Centre being headed by an eminent engineer is only a recent phenomenon. An implicit equation has been made between any *average* IAS officer and an *eminent* engineer or scientist. No *average* engineer can hold such posts As for the states, even where a chief engineer has been made ex-officio secretary to the government, it has not been possible for him to exert his technical influence due to the preponderance of the non-technical bureaucrats surrounding him in the secretariat whose opinions alone count with the politicians in power.

DISASTER AHEAD

Reading J P Naik's article on educational policy (Viewpoints, November 1979) makes the reader elated to know that, for once, someone at the top is concerned about the odd social and economic conditions prevailing right from the school-level education But his final sentence leaves one scared. He too forsees only disaster because of the indifferent attitudes of the persons concerned with the purpose and aims of education

Manmohan Singh
Research Scholar
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IIT, Madras 600 036

A facade to perpetuate the old health care system?

IN APRIL 1977, the Union Ministry of Health and Family Welfare made an assessment of the health services in the country. The aim was to launch a new nationwide health programme intended to give "People's health in people's hands". Two years later, in the wake of India's acceptance of the Alma Ata Declaration on Primary Health Care, which entailed attaining the goal of "Health for all by 2000 AD", the Government of India formulated a much wider health policy; it incorporated the programme of "People's health in people's hands", also called the Rural Health Scheme or the Community Health Workers or Volunteers Scheme.

The Union Ministry of Health and Family Welfare has, in fact, painted a grim and gloomy picture of the health status of the people of India *(Health Care Services in Rural Areas: Draft Plan 1977)*. It says, "After thirty years of independence, even after setting up 5,372 Primary Health Centres and 37,775 sub-centres, we have not made a significant impact on the health status of the rural populations and the rural poor. When judged by the three simple yardsticks, literacy, life expectancy and infant mortality, our country comes low down in the Physical Quality of Life Index (PQLI), with some areas of the country competing for the bottom-most position in the world. This is the position in spite of the hoary traditions of the past extending over 5,000 and more years of recorded history and in spite of a large number of practitioners of the traditional systems of medicine like Ayurveda, Homoeopathy, Unani, Sidha, etc in the rural areas. It should make us pause and think as to whether the investment in rural health so far made has been of the right order and in the right direction and has used the appropriate technological processes."

These findings were also underlined by a committee of the Government of India *(Report of the Committee on Utilisation of Beds in PHCs, 1974)* which observed: "Almost all the national programmes have suffered because they have not received adequate attention from the medical officer in-charge and his team of paramedical workers. In most of the Primary Health Centres, the lady health visitors, the auxiliary nurse midwives and other paramedical workers are not available in the required number. Even when they are available, they are comparatively young and inexperienced and they have failed to win the confidence of the community and their impact on the community is negligible. Because of the failure of lady health visitors and auxiliary nurse midwives, the untrained *dais* are preferred by villagers. Ignorance, apathy, fear and lack of confidence among the paramedical staff at large are responsible to a considerable extent for underutilisation of the capacity of these workers."

Meanwhile, over three-fourths of the total number of mothers in the country cannot get even the services of an auxiliary nurse midwife at child birth. This accounts for the still very high rates of maternal morbidity and mortality. A vast population does not even get protected water supply and the most elementary facilities for environmental sanitation. Tens of millions continue to fall victim to such easily preventable diseases as cholera, dysenteries, enteric fevers, hepatitis, poliomyelitis and various worm infestations. Despite very heavy investment in specialised national programmes against leprosy, filariasis, cholera and trachoma, it has not been possible to make any epidemiologically significant dent in these areas. Widespread poverty, hunger, malnutrition, poor housing and environmental sanitation and an overwhelming sense of helplessness, frustration and dejection have created an ecological setting which accounts for the very high rate of infant mortality and morbidity in the country. Half of the population living below the subsistence level suffers from serious undernutrition and malnutrition.

Social, economic and political determinants of health services

The above account of the health services provides a good example of the social, economic and political factors which influence the role of science and technology in a country. Even though there have been myriad of breakthroughs in the medical sciences, most of the easily preventable or curable diseases continue to cause enormous suffering to millions in India, because they have no access to some of the most elementary forms of medical technology.

What do these breakthroughs then mean to these people? And how is it that, at the same time, the latest and most sophisticated medical technology is available to the more privileged classes, often free of cost, from community-financed health institutions? Why is it that social scientists, health educators and social workers have grossly distorted the concepts and methods of their disciplines to project a grotesque image of the health behaviour of the deprived sections of the population? Why has education and training of physicians not been socially oriented in spite of all the raucous debates on this during the past 32 years? Answers to such questions are to be found by studying the social, cultural, economic and political dimensions of the medical sciences in India.

Medical scientists have, however, not paid adequate attention to these dimensions. Worse still, most of the key persons in this field have a vested interest in actively resisting any change. Not only is the perpetuation of the high-technology medical services, which subserve the privileged urban gentry, highly lucrative and professionally satisfying to physicians, but it also pays rich political dividends because the political leaders themselves need such technology. It is significant that *all* the physicians to be awarded the Padma Bhushan were associated with high-technology medicine; many of them got noticed because they provided personal services to important political leaders.

The Janata government of 1977 exhorted people to popularise auto-urine therapy, naturopathy, yoga, Homoeopathy, Ayurveda and Unani systems, but when an apical lesion was discovered in the lung of the President of India, cancer specialists at the All-India Institute of Medical Sciences, New Delhi, and the Tata Memorial Cancer Hospital, Bombay, used the occasion to extract huge funds from the same government for buying highly sophisticated linear accelerators for their institutes.

And more recently (November 1979), the very person who, as Union Health Minister, was so deafeningly vocal in exhorting people to take to Ayurveda, Unani, etc did not hesitate to keep a room in the Ram Manohar Lohia Hospital in Delhi occupied for days together for treatment of a minor head wound. Never mind the inconvenience and pains caused to hundreds of other patients, harassment of the hospital staff and all the arrangements that had to be made to serve the lavish food he ordered.

Adoption of such a double standard forms part of what anthropologically can be called the culture of the health services system. The culture of the medical scientists, the culture of the political leadership, the culture of the administrative machinery and the culture of the health establishment in affluent industrialised countries, from which all the other three groups derive their inspiration, form the culture of the health service system in India.

The National Health Policy

It is against this cultural background that the recent National Health Policy should be seen. This background provides two different contexts to the policy. In one, it is seen as yet another effort in a series of earlier health policy efforts which remained ineffective, either because of some intrinsic limitations in the policies or in their implementation, or both. In the other context, this policy marks a major watershed in the development of the health services in the country.

Let us first trace the history of our health policy. As early as 1946, enunciating the health policy of independent India, Jawaharlal Nehru endorsed the recommendations of the Health Survey and Development Committee, 1946 (Bhor Committee). This committee had drawn up a blueprint for a health service which paid much greater attention to rural populations, preventive services and social orientation of medical education and training, ensured free access to health services by all citizens and linked the health services with overall developmental efforts; this, however, remained an empty slogan because the programme of establishing Primary Health Centres, started in 1952, turned out to be a much watered down version of what was envisaged by the Bhor Committee. The 1950s saw policies to launch national campaigns against major diseases such as malaria, smallpox, tuberculosis, leprosy, filariasis, cholera and trachoma. Since the early 1960s, there have been major efforts in the field of family planning. Later efforts were made to integrate the national campaigns and the family-planning programme with the Primary Health Centres. More recently, the policy is to train multipurpose health workers so as to integrate all health and family planning activities at the village level. This scheme is still in the process of implementation.

The April 1977 health policy statement, entrusting the responsibility of "People's health in people's hands", makes a major departure from the earlier trend. Essentially, it seeks to democratise health services; it envisages that the entire health service system be moulded by the people themselves, and not by administrators, technocrats and political leaders. The two cornerstones of this policy are: (a) encouraging people to cope with their health problems in their own ways, and (b) ensuring that the tools of health technology are placed under the control of the people themselves. In other words, it subordinates technology to people, instead of subordinating people to a pre-determined, pre-packaged technology generated in the consumer societies of the affluent industrialised countries. This policy incorporates Ivan Illich's concepts of demystification, deprofessionalisation, decentralisation and decommercialisation of health technology. The essential innovative elements of the barefoot doctor movement during the Cultural Revolution in China are also present.

The National Health Policy, 1979, of which the 1977 health policy statement is a key component, promotes decentralisation of the health services. Its specific elements are: (1) close linkage of health services with other developmental activities; (2) reorganisation of health services to meet the needs and aspirations of the common man and to ensure equitable access to health services; (3) active involvement of people in coping with their health problems; (4) promotion of community self-reliance and a reduced dependence on professional intervention; and (5) inculcating the right attitude and technical skills in agents of health care through suitably designed programmes of education and training.

The document also contains a refreshingly new approach to medical research: "Health services research is holistic, multidisciplinary in character, involving joint participation of biomedical sciences and social sciences. Such research should be carried out within the health service system and research priorities determined as a result of joint discussion between researchers, administrative decision-makers and the public. The whole ethos of such research should be based on the discovery of simple, low-cost appropriate technology, the results of which are applicable under routinised settings."

The question of implementation

But implementation of a policy with such far-reaching implications requires fundamental changes in the culture of the health service system—in fact, a virtual revolution. That the government does not really mean what it propounds in its policies becomes clear as one reads through the rest of the document on the National Health Policy. Having made all the good and desirable statements, it takes up such issues as mental health, rehabilitation, bioengineering, pharmaceuticals and legislation, insurance and coordination. All such profound pronouncements turn out to be mere platitudes when it comes to concrete action programmes. For instance, in the short-term goals, the policy talks of eradication/control of communicable diseases, providing adequate health infrastructure, health education, use of different systems of medicine, re-orientation of medical education and provision of maternal and child health coverage. This is all too familiar, a recurring theme, first stated in the health chapter of the first Five Year Plan, repeated in the second, then carried to the third, the fourth and now to the fifth plan. Indeed, the National Health Policy has only widened the credibility gap. For there is a pronounced administrative lag in bringing about changes in health administration in tune with the new policy. And one fears that the policy may only be a facade to perpetuate the old system.

Over two years' experience with the Community Health Workers' Scheme confirms the fear that this administrative lag will corrode the very soul of the programme. More often than not, it is not a people's programme in practice.

How does this happen? The Community Health Worker (CHW) often comes from the privileged classes; those who need his services most have little or no access to him. His trainers are most ill-suited to train him (for example, he is trained to teach people to eat chicken legs to improve nutrition!) and, in any case, he has little motivation to receive training. And, though the idea was to have him under control of the community, he is more often governed by bureaucrats, or at best by a consortium of bureaucrats and village bosses. Also, he wants to become a "doctor"; the rest of the health service system looks down upon him and does not provide him the support which is so vital for the success of the programme. In the process, people who need help so desperately are left high and dry.

The muddle of the "Model Plan"

The same administrative blunders are sought to be repeated in the implementation of the Central Government's "Model Plan". This plan implies doubling the present health services infrastructure. In effect, this means doubling the inefficiency, waste, corruption and incompetence that has been the hallmark of our health service system. The government is also seeking assistance from the World Bank and the United Nations Fund for Population Activities (UNFPA) and also from Sweden, Denmark and the UK, to get yet another opportunity of making a gigantic mess of the health services.

Thus the very government, which swears by democratisation of the health services and multidisciplinary research to improve the quality of the health services, finds nothing contradictory in pushing on with an utterly muddle-headed "Model Plan" and seeking credits and grants from the World Bank and other foreign agencies to provide funds!

The alternative

One may well ask why the decision-makers should come out with such a radical policy about changes? An answer to this can be that they were forced to do so by the sheer compulsion of the political situation, and having given in, they came back to sabotage their own policy to give a further lease of life to a system in which they have an entrenched interest. The logical solution to the problem, therefore, lies in mounting further political pressure on the system so that the policy commitments become a reality.

An alternative health care delivery system for rural India must start with the people. Instead of fitting people within a pre-determined framework of health services, a framework should be designed for a health service system which is specially tailored to suit the requirements of the people. The technological elements of the health services must be subordinated to the requirements of the people; these elements should be designed such that they are in consonance with the pre-existing health behaviour and the pre-existing health institutions and health care delivery agencies in the community; that they fit in well with the social and cultural setting; and that they can be made available for this purpose. In other words, people should not be "educated" to discard the health measures that they have been adopting earlier unless a convincing case is made to show that, taking into account their perception of the problems and under the existing conditions of resource constraints, it is possible to have an alternative technology which will yield significantly greater benefits in terms of alleviation of suffering caused by health problems.

While it is being gradually realised that it is unrealistic to expect improvement in the health status of the population of a country without appropriate political, economic and social action, it is often overlooked that efforts to alleviate the suffering caused by health problems can, in its turn, contribute to the initiation of such actions. In this context, formulation and implementation of an alternative health care delivery acquires considerable significance.

D. BANERJI

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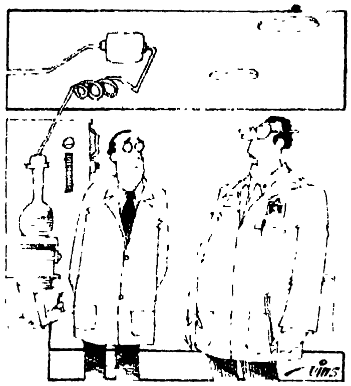
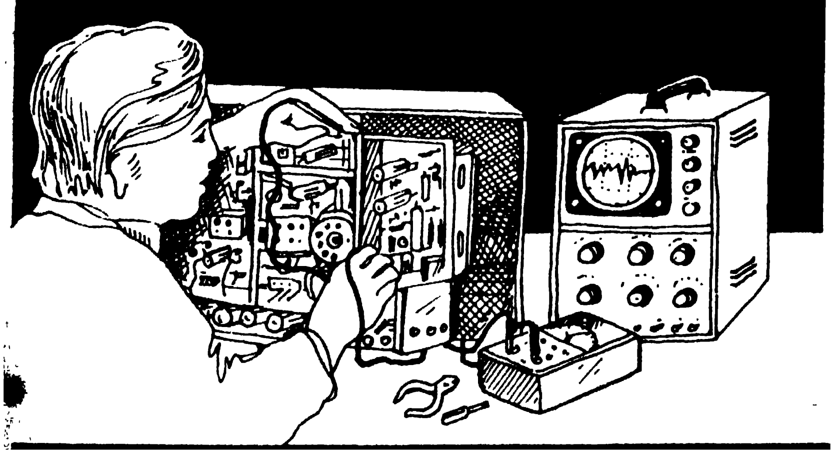


"You have got the grant at last. But remember, for every ten thousand rupees, there must at least one breakthrough."



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Milk schemes turning sour

IN THE 1950s, two Indian dairy scientists went to see dairy plants in New Zealand. What they saw in one of the factories, making skimmed milk powder (SMP) struck them: the powder was flowing through a big channel right into a piggery. While babies in India went without milk, in New Zealand SMP was fed to pigs. Why not buy the SMP, the scientists wondered, reconstitute it as liquid milk and supply to Indian cities?

That was the beginning of SMP imports which unfortunately has become the basis of dairy development in India. In 1960, about 18,793 tonnes of SMP were imported at Rs.32.5 million. It rose to 27,772 tonnes in 1977, valued at about Rs.260 million. When it was known that India was buying SMP for human consumption, the price was hiked from Rs.1,500 a tonne in 1960 to Rs.2,000 in 1974 and Rs.8,000 in 1979.

When the National Dairy Development Board (NDDB) launched "Operation Flood" (OF) in 1970, it went a step further and imported butter oil. So thanks to OF, butter oil and SMP now come to India as "gifts" from the European Economic Community (EEC) countries where mountains of SMP and butter oil had piled up, their disposal creating a problem. The EEC countries, which do not use SMP for human consumption, found it convenient to dump it on India. Today India has become as dependent on gift SMP for its urban milk supplies as it used to be on PL-480 wheat imports in the 1960s. And just as PL-480 wheat gifts thwarted indigenous food production, gift-wrapped SMP and butter oil are threatening indigenous cattle development and dairy technology.

In simple terms, this is what is happening: India exports cattle feed to EEC and other countries to fatten their cows. These countries send milk powder to India. The money generated by selling the recombined milk in India goes back abroad by way of orders for dairy equipment to process more of the imported SMP. Is this arrangement correct? Of late, many dairy experts have become sceptical. Will the new government give a serious thought to this policy before operation milk turns sour?

Look at India's resources in this field. She has about 180 million cattle, about 60 million buffaloes, best-equipped dairy research centres, and veterinary and fodder research institutes. Yet milk is a luxury in India where the urban population does not drink the wholesome cow or buffalo milk but milk reconstituted from imported SMP and butter oil. In 1947, an Indian consumed, on an average, 200 grams of milk a day. Today, a decade after OF was launched, he consumes only 110 grams. To take an example, before OF, visitors to any village in Haryana used to be offered milk or *lassi*. Now they are greeted with tea. In fact, the per capita milk consumption in villages is only 86 grams. OF has thus drained away milk from rural areas to metropolitan cities. Milk is also diverted to make 40,000 tonnes of baby food a year. No wonder, therefore, that at times milk price in Rohtak, a milk producing centre in Haryana, used to be higher than in nearby Delhi.

Under the OF scheme, India was gifted 126,000 tonnes of SMP and 42,000 tonnes of butter oil. The NDDB had planned to raise Rs.1,160 million by selling the recombined liquid milk and use this amount for improving cattle and developing dairy technology in the country. But nothing of this sort happened. Instead, about Rs.600 million was spent on milk processing equipment, most of which were imported from suppliers of gift SMP

In other words, committing Indian dairies to imported SMP has helped to sustain the dairy equipment manufacturing industry in EEC and western countries. The import of hardware included complete plants to make the controversial "tetrapak" milk containers from Sweden, liquid nitrogen containers (for storing semen) from the USA and France, and stainless steel barrels for rail milk tankers from New Zealand, to name a few.

Meanwhile, milk production did not increase in India under OF as the scheme failed to address itself to cattle improvement and feed and fodder development. Naturally, many dairy technologists are not enthusiastic about the extension of OF — under the name "Operation Flood-II" — with a World Bank loan of over Rs.2,200 million and gift SMP and butter oil worth around Rs.2,500 million. Inaugurating OF-II, the former Prime Minister, Mr. Charan Singh, said bluntly that he had doubts about the nature of the programme and "how far it was designed to meet the problems of livestock management or upgradation of the real standards of the poor".

The National Commission on Agriculture (NCA) has estimated that milk production should increase from the current 25 million tonnes a year to 44.17 million tonnes by 1985 and 64.4 million tonnes by AD 2000. This target is again unlikely to be reached, unless there is stress on cattle improvement and feed and fodder development. According to dairy experts, milk production in India can be increased by 50 to 60 per cent by simply feeding the animals well. For instance, D.N. Khurody, a noted dairy expert of Bombay ("A story of neglect", Science Today, September 1973, p.42) asks why the World Bank, if it is really interested in dairy development in India, cannot provide milk powder in the form of "calf-starters" to feed the starving calves, and feed-concentrates for the underfed adult animals. Should Indian cows be starving, while oil-cakes and other feeds are exported? One kilogram of feed-concentrate can help a cow yield 2 kg of milk. The 1.4 million tonnes of cattle feed exported in 1977 was thus equivalent to 2.8 million tonnes of additional milk, about ten times the quantity of SMP that came as gift under OF!

A challenging task that the Indian dairy scientists face is to raise the per capita consumption of milk to 200 grams a day as recommended by nutritionists. As stressed by the NCA in its report, the biggest bottleneck will be dry fodder and feed concentrates. In many parts of the world, urea is used as a protein substitute for ruminants to enrich poor quality fodder and as an additive in concentrate mixtures. Why is it that none of the 20 cattle feed factories in the country make feed-grade urea? Besides, a large number of by-products, which are scarcely used now, can be used as nutrients for livestock. These include forest by-products like salseed cake, mahua flowers, mahua cake, rubber seed cake, tapioca meal, and seeds of mango, jamun and other fruits. Protein from leaves, algae, sea weeds and waste from the antibiotic industry are also potential cattle feeds that need to be introduced in any plan under the white revolution.

Scientists have also now realised that the much-maligned goat deserves a second look as a possible alternative source of milk, meat, manure and hides. Today goats contribute 600,000 tonnes to the country's milk pool, and there is scope for genetic improvement of Indian goats ("On scientific breeding of goats", Science Today, July 1977, p.25). In a rural set up, goat-rearing is considered economical as a farmer can have 20 goats for the price of one cross-bred cow. The nutritional status of these groups will also considerably improve.

K.S. JAYARAMAN
Dr. Jayaraman is Science Correspondent of the Press Trust of India, New Delhi.

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Why do things go wrong?

Cussedness is a law of nature. Engineers are too familiar with the Law of Natural Cussedness, the Sodd's Law and the Murphy's Law. Most of them, some time or the other during their work, have had to face harrowing moments, arising out of the implications of these laws. Although people from other professions may not be aware of them, they too may have often wondered why things go wrong as they do during crucial moments. It may, therefore, be worth quoting the following article by D.A. Duncan, a senior engineer working on the design of a North Sea oil platform. Duncan explains why things tend to go awry exactly when they ought not to. This article originally appeared in Chartered Mechanical Engineer, *the journal of the Institution of Mechanical Engineers, UK.*

Whereas modern engineering education aims to ensure that would-be mechanicals (or other breeds of engineer) are at least acquainted with such natural laws as those of thermodynamics, there appears to be little, if any, coverage of more general, but equally valid other natural laws. The first of these neglected laws is one which the engineer soon comes up against when he learns to apply his theoretical knowledge during his graduate apprenticeship, if not earlier, when he is trying to repair his car, motorcycle or bicycle. It has been given various titles, but the currently preferred one is The Law of Natural Cussedness—which states that *"Every inanimate object tends to take up a position of maximum inconvenience to the engineer."*

One of the earliest confrontations with this law occurs when as a lad the engineer goes to inflate his bicycle tyre. It is discovered that the wheel has stopped with the valve exactly between the frame members, and therefore the wheel has to be further rotated before the valve is accessible. Later on in life, the manifestations of this law become more difficult to circumvent. When a lift fails, it stops not opposite the doors, but opposite five feet (sorry 1524 mm) of reinforced concrete between floors.

In earlier years this law was treated with much deference. At the turn of the century a steeple-jack working at the top of a chimney dropped his sandwich lunch, which fell 300 ft (they didn't have to worry about metres in those days) to the ground. When he went to retrieve it, he found the sandwiches had opened, and landed butterside up. As this was patently contrary to the Law of Natural Cussedness, he was extremely worried until a learned friend explained that he had no need to worry: the reason was very straightforward, his wife had buttered the wrong side of the bread.

The second of the natural laws has only recently been accurately formulated, but many years ago it was postulated by Arkwright Sodd, whose name is now given to the law. Sodd's Law: *"When the normally calculated mathematical probability of the occurrence of an extremely adverse event or simultaneous combination of events is very small, then on the one occasion when it is of significant importance to the engineer, the actual probability of such an event or combination of events occurring on that one occasion is very nearly 100 per cent."*

When the Kariba Dam on the River Zambesi was being built in the late 1950s, it was necessary to protect the partially completed sides with cofferdams during the rainy season. From a study of the sides of the Kariba Gorge and from river depth records going back over 50 years, the highest water level was ascertained and the cofferdams were built some feet higher than this. Yet when the rains came, the river rose not just to the highest level attained in 50 years, nor to the top of the cofferdam, but to some 3 metres or more higher than the cofferdam. Had construction started a year earlier or a year later those same cofferdams would have been more than adequate.

A driver took his car back to the garage where it had been serviced two days previously, complaining of an intermittent knocking noise in the engine. Only after thorough investigation was the cause located. The spring-loaded ball from the socket drive tool used by the mechanic had sprung out whilst the sparking plugs were removed for cleaning, and had entered the combustion chamber via the spark plug hole. The knocking noise had been caused by the ball embedding itself in the piston head, working loose, then bedding itself in again. The mathematical odds against the ball coming loose at all, let alone at a time when it could enter the engine, and taking the right trajectory so that it could go down the spark plug opening are very small indeed, yet it happened on that one occasion.

These two true examples serve to illustrate (as will, no doubt, the recollections of most engineers) that Sodd's Law is as valid today as ever.

Sodd's Law, or its well-known counterpart, Murphy's Law, can be stated mathematically as $1 + 1 \quad 2$, where the symbol means hardly ever. For the interested reader, here are a few of the developments on the basic law.

Although the general law is well known, applications of the special laws are not so well documented. To rectify that deficiency, the following samples are given.

1. If anything can go wrong, it will during the demonstration.
2. All warranty and guarantee clauses become void on payment of invoice.
3. Firmness of delivery dates is inversely proportional to the tightness of the schedule.
4. Dimensions will always be expressed in the least usable term. Velocity, for example, will be expressed in furlongs per fortnight.
5. An important instruction manual or operating manual will have been discarded by the Receiving Department.
6. In any given calculation the figure that is most obviously correct will be the source of error.
7. In production engineering wires cut to a specified length will be too short.
8. The availability of a component is inversely proportional to the need for that component.
9. If a project requires X number of components, there will be X -1 in stock.
10. A dropped tool will land where it will do the most damage (also known as the Law of Selective Gravitation).
11. A device selected at random from a group having 99 per cent reliability will be a member of the 1 per cent group.
12. When a 3-phase electric motor is connected to the power supply, it will be found on starting to be running in the wrong direction.
13. Probability of failure of a component is inversely proportional to the ease of repair of replacement.
14. The most delicate component will drop out first.
15. A transistor protected by a fast acting fuse will protect the fuse by blowing first.

Incidentally, Murphy's Law, in general, states that "If anything can go wrong, it will go wrong." My proof of this law is, "If nothing goes wrong, then Murphy's Law goes wrong. Q E D"

M M SIVARAMAKRISHNAN

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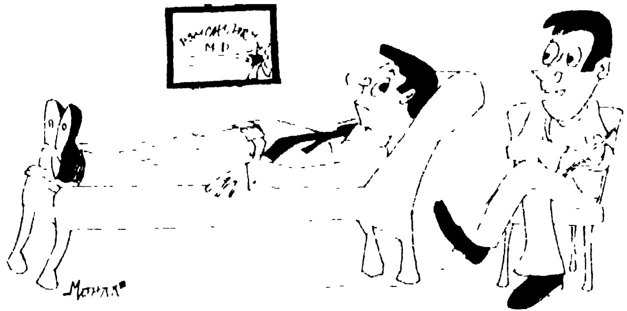
Science Shapes Life

HEALTH IS IN THE HEAD

Salvedor Chindoy is an American Indian medicine man from an Amazon tribe "Drugs", he says, 'make you feel good in the head which result in your body feeling good." Chindoy who is in his seventies should know. He has been eating hallucinogenic plants since he was six

Eloy Rodriguez of the University of California, Irvine, USA, who studied the Kamsa Indians of the Amazon, also feels, after combining his field observations with laboratory work and historical study, that the psychoactive drugs might indeed have had beneficial effects on the health of the consumers.

Many of these plants, says Rodriguez, are eaten routinely for religious or social purposes. Many of them are toxic and induce vomiting and purging, in much the same way as modern drugs used for parasitic infections do. Since, in the tropics, parasitic infections are a regular menace, it is possible that these drugs cured the infections simultaneously while producing hallucinogenic effects and so the Indians linked up the mental wellbeing with good physical health That may be the reason why the elderly medicine man who began taking the drugs in early life continued to do so—for social reasons



Diagnosis yours is a sound nut case in a sound body!

DYNORPHIN THE SUPER OPIATE

Biologists at the California Institute of Technology (Caltech), USA, have succeeded in sequencing 13 residues of the brain peptide, dynorphin Dynorphin, a peptide found in the posterior part of the pituitary gland, has been a difficult compound to study. Discovered in 1975, it escaped purification because it was 'sticky' it adhered to the experimental glassware and got lost

The scientists who have succeeded in sequencing the 13 residues from 2 micrograms of dynorphin are Michael Hunkapiller and Leroy Hood. They found, however, that the first five residues of the peptide were none other than leucine-enkephalin.

For long, scientists have been trying to find large peptides containing this compound And now they discover that unlike m-enkephalin which is more potent than its precursor, beta-endorphin, l-enkephalin is much less potent than the 13 residues of dynorphin This segment is almost as potent as the entire dynorphin which in turn is 700 times more potent than l-enkephalin

Avram Goldstein, of the enkephalin fame, and his colleagues are now working on the radioimmunoassay of the dynorphin molecule Other studies will be aimed at localising the active region by chopping off one residue at a time and also stabilising the compound against breakdown

Since opiate-like peptides are involved in pain regulation, scientists hope that research would lead to the synthesis of more effective and less addictive analgesics.

Correction

In the second line of the item "Cloudy Neptune" (Science Shapes Life, January 1980, p.15), "30 AU (Angstrom units)" should read as "30 AU (astronomical units)".

NEW MALE CONTRACEPTIVE USES TB VACCINE

While there has been some controversy over the anti-pregnancy vaccine (see Letters, September 1978) being developed by G.P. Talwar and others at the All-India Institute of Medical Sciences, New Delhi, there comes news of a totally different birth-control technique from the same group.

The method, which is directed at guiding the body's immune system against cells that produce sperm, makes use of the tuberculosis vaccine, bacillus Calmette-Guerin (BCG) The vaccine was injected into the testicles of these animals. Talwar and his co-workers claim that the vaccine has worked well with primates and other mammals. They now hope it will one day be available also for clinical use.

So far a major problem with all male immunological contraceptives has been that it reduced the sex drive. But these researchers say that the TB vaccine has no such side-effect. They are not sure though that the process itself can be reversed.

MAGNETIC MATS FOR MUSLIMS

Globe-trotting, devout Muslims may have a small problem at prayer time How must they align themselves so that, while praying, their heads point to the holy city of Mecca A Swiss inventor says he has solved the problem. He has designed a prayer rug with an inbuilt compass and a map that translates the compass readings and indicates the exact location of Mecca

This is how it works. The major cities of the world are marked on the map in the centre of which is the compass To pray, the devotee has to spread the antistatic rug and wait till the needle stabilises and points north He then has to rotate the rug so that it is in line with the city where it is being used Once this is done the mat will be automatically facing Mecca

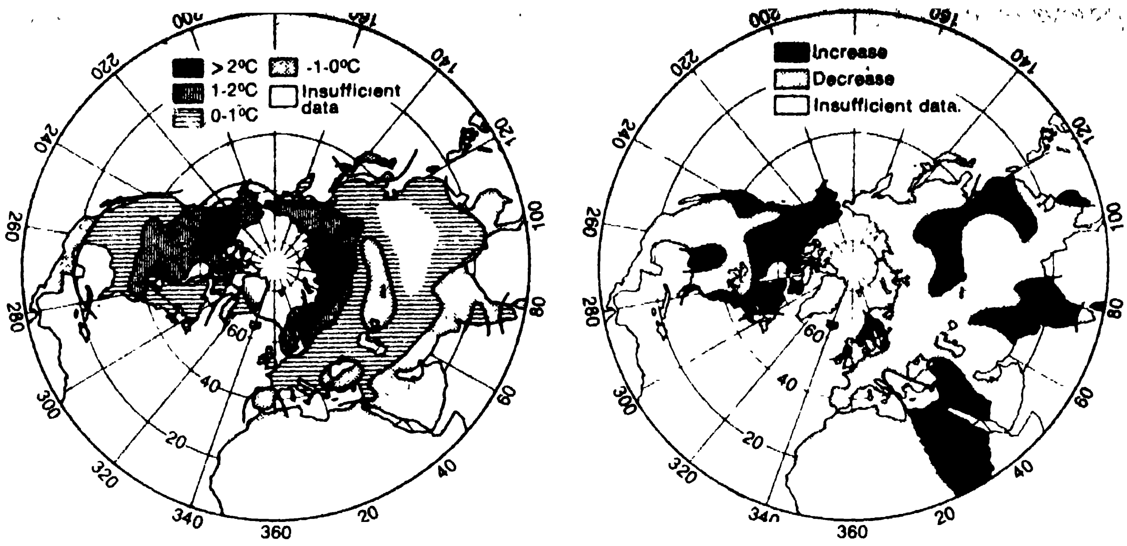
The inventor, Joseph Kamoo, has applied for a European patent

'It will do the West good if they also fix a compass somewhere on Ayatollah Khomeini "

RING AROUND THE SUN?

Rings have been discovered around the planets Uranus and Jupiter (SCIENCE TODAY November 1979). And now there is speculation that Neptune might also have a ring. "Can the sun also have a ring of rocky and particulate material around itself?" ask Brecher and his colleagues of the Department of Astronomy, Boston University, USA

The Titius Bode Law and Blagg's Law indicate an orbit for a body within the orbit of Mercury some 25 million kilometres from the sun. A large body at such a distance would be dragged inward by the sun's gravitational force until it disintegrated at a distant about twice the radius of the sun and formed a ring.



If the atmospheric carbon dioxide increases and the earth warms up, Fig. on the left shows the likely temperature changes. Fig. on the right shows the corresponding changes in rainfall

INDIA WILL BE WETTER...

...if atmospheric carbon dioxide content doubles and raises the global temperature by 2°C. And why should the carbon dioxide level go up? Because, the burning of fossil fuels and large-scale deforestation are upsetting the natural climatic balance.

The atmospheric concentration of carbon dioxide which was 300 parts per million (volume) in the late 19th century is now 330 ppmv. And this, it is believed, represents only half the amount released by human activity. The other half has been absorbed by the oceans. If this trend continues, and the carbon dioxide content of the atmosphere doubles, the various models suggest that the overall temperature increase would be about 2°C. As a result, the climate might change.

How would the increase affect the global climate? A team of scientists, T.M.L. Wigley, P.D. Jones and P.M. Kelly from Climatic Research Unit of the University of East Anglia after looking at the record of warm years from 1924 to 1970, have deduced that earth would heat up. The warmth would be produced by the greenhouse effect of the carbon dioxide in the atmosphere. Winters of the overall warm years, they found from the records, were 1.8°C warmer than those of the overall cold years. The difference in summer temperatures was 0.7°C. Using the climatic fluctuation between these two extremes as a reference guide, the East Anglia scientists say that world precipitation would increase by 5 per cent. While it would decrease over much of Japan, Russia, Europe and the USA, over the Middle East and much of the Indian subcontinent, it would increase. Sizeable regions where precipitation is expected to decrease lie in the agricultural belts.

What could be the material this ring would be made of? What is its aggregate and its position? If such a ring did exist, first, the material would have to be highly refractory to withstand the high temperature (a few thousand degrees) it would reach due to the nearness of the sun. Carbon, in the form of graphite, seems to be the most likely material. Also, the ring would have to be at about 3 million kilometres, or four times the radius of the sun, in order not to reach too high a temperature. It has to be in chunks of size 10 kilometres or more in size to survive drag effects.

The total mass in the ring is estimated by its possible effect on Mercury's orbit. It is well known that the orbit of Mercury is elliptical and the closest point to the sun (called perihelion) is seen to move around slowly (43 arc seconds per century). This movement is explained by Einstein's General Relativity Theory which predicts almost exactly the observed value with a small uncertainty. If one assumes that the ring produces an effect on the orbit of Mercury less than a hundredth of that predicted by General Relativity, the mass in the ring turns out to be less than about a hundredth of the mass of the earth. This mass will be in about a million chunks orbiting around the sun. They might be visible individually during a solar eclipse, but they would be dim indeed and would need fairly big telescopes to see them.

BURNS VACCINE?

It doesn't prevent you from getting burnt, but prevents post-burn infections which are responsible for the complications that frequently occur. One of the main infections is due to *Pseudomonas*. Roderick Jones and his colleagues at the MRC Immunology Unit, Birmingham Accident Hospital, have developed the oral vaccine from the killed bacteria.

Full-scale trials were carried out in New Delhi and in Birmingham and it was found the vaccine could save lives. Also, the vaccine could stimulate immunity within a couple of days of administration. The antibodies level stayed high for three weeks, after which it levelled off. In the Indian trials, the vaccine was found to reduce mortality by more than a third. The plasma of the inoculated persons was also found to contain a high level of antibodies against the germs and transfusing blood from an inoculated person was as effective as the vaccine.

How does the vaccine help? For one, it can combat bacteria which otherwise are kept at bay by using antibiotics. In the case of *Pseudomonas*, this method of infection control is undesirable because the bacteria usually develop resistance to the drugs, rendering them ineffective. Vaccines avert this complication.

Jones and his team plan to extend the vaccine to cover other infections as well. For this, they will have to use the respective bacteria. Such a vaccine would also be very useful for transplant patients who have to take drugs to avoid infection and for leukemia patients, whose resistance is low. Also, the anti-infection vaccination would be useful for high-risk people like firemen.

SQUARE BUGS OF SINAI

They aren't any more old-fashioned than other bacteria. If you looked at them through a microscope—that is the only way you could—they appear like a sheet of postage stamps.

Bacteria usually come in rounded shapes: sperical, rod-like, corkscrew-like and many such other forms. This is because water from the surroundings enters their body continuously, due to osmosis, increasing the pressure inside.

How then do square bacteria remain square? The answer is simple: it's because they live in salt water and,

The square of the microbial world. A newly discovered *Halobacterium* (salt tolerating bacterium) shows tiny gas-filled vacuoles that serve as buoys, as bright spots

there is no inflow of the surrounding fluid into their body. In other words, they have no turgor pressure and so their overall shape depends on the shape decided by the structure of their cell membrane.

It was Tony Welsby of the Marine Science Laboratory, Menai Bridge, Israel, who spotted these germs. It was while he was microscopically scanning samples of water from an extremely saline coastal pool in the Sinai peninsula for bacteria that kept afloat by means of gas-filled balloons inside them, that he came across these new squares. They belong to the *Halobacterium* group. And they too have tiny gas-filled sacs within to buoy themselves up.

KNOCKED OUT BY AN ASTEROID

Sometime around 65 million years ago a drastic event occurred on earth. The dinosaurs and about half of the genera of plants and animals died. They were wiped out. As for how it happened in the case of the giant reptiles, a number of biological and environmental causes have been suggested. But now comes a new hypothesis that states that the catastrophic event that led to the mass extinction of various forms of life was triggered by an asteroid. Its authors are Luis Alvarez and his colleagues from the University of California, Berkeley, USA.

They announced at a meeting of the American Association for the Advancement of Science held in San Francisco, USA, in January that they had found clues that a 10-km diameter asteroid had hit the earth. They have found this evidence in a stratum of clay which has high iridium content corresponding to that period.

On earth, most of the iridium is concentrated in the core, and very little is found in the clay layers. However, there are specific layers, 65 million years old, which have 30 to 160 times more iridium than the other strata. This iridium they suggest must have an extraterrestrial origin, maybe an asteroid. If they hit upon more such finds, it should confirm their theory.

This is how, they say, it all happened: The huge asteroid raised enough dust to block out sunlight for three to five years. So photosynthesis ground to a halt, starving several land plants and marine plankton to death.

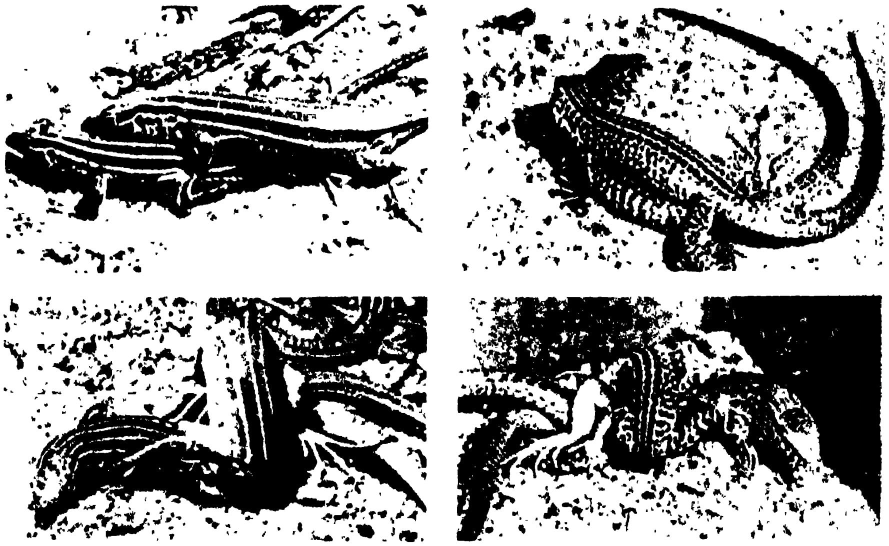
They being at the base of the food chain, for many other life-forms it was almost as if the rug had been pulled from under their feet. They too perished. Only those animals that could adapt to nuts, seeds and decaying plants did tide over the catastrophe. Where is the crater of this deathdealing asteroid? None has been found so far. But, the Alvarez team argued, since the debris of such an impact would have deposited a distinct layer in the sedimentary rock, they must look for such a layer. They searched, and finally did find such layers in Gubbio in Italy and in Stevns Klint in Denmark. These were the high-iridium containing layers.

Although small quantities of iridium do drift in from space, they say only large asteroids could bring in such large amounts. Happily, a big meteor impact like that can occur only once every 100 million years.

GAY LIZARDS

Some reptile species consist only of females. So, for them sexual reproduction is out of question. But, recently, an unusual mating behaviour was noticed in one such species of lizard. This species, *Cnemidophorus uniparens*, behaves exactly like its relative, *C.tigris* which consists of both males and females. But what these lizards indulge in may, at best, be called pseudomating. In this pseudomating performance, age and size of the partners do not seem to matter in the roles—male or female—they play. All that matters is the stage of the ovulatory cycle of the animals. David Crews of Harvard University and Kevin T.Fitzgerald of the University of Colorado who reported this strange behaviour had other interesting facts to recount. Of the two courting lizards, the more aggressive one contained only undeveloped follicles in her ovary. But the lizard that played the female role had fully developed follicles. The scientists explain that pseudomating probably stimulates hormone production that encourages reproduction.

How do they pair off? Crews and Fitzgerald even noticed the same animal playing both the sex roles. When estrogen was administered to lizards in various stages of their ovulatory cycle, it did not make them attractive. Only preovulatory lizards were sexually attractive. A 'mated' lizard laid eggs 30 days later. Though lizards in solitary confinement do reproduce, the rate is much slower than of those raised in groups.



Two pictures on the left show the pseudomating *Cnemidophorus uniparens* as compared to the mating of the closely related species *C.Tigris*. Note the similarity in positions. Crews and his colleagues are now treating *C.uniparens's* eggs with hormones hoping to create males in the altogether female species. The hatchlings from treated eggs were found to have developed male-like reproductive organs.

Advt. No. 24/9/79

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HEADS OF DIVISIONS

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Candidates should have high academic qualifications in Science or Engineering and excellent record in research relevant to the areas mentioned above. Experience in leading a group of research scientists or engineers and in the management of research and application of research results would be desirable.

The Research Centre has excellent facilities for research work in the fields and further additions are being made. It is planned to increase total personnel from the present 80 to 250. The Corporation has commissioned and is operating a Rs. 400-crore complex and produces aromatics, olefins, polymers, fibre intermediates and fibres as well as wide range of basic organic chemicals. Further expansions are in progress.

The positions are in the scale of Rs. 2000-2500 and the total emoluments at the minimum of the scale are Rs. 3020 p.m. In addition medical facility, leave travel assistance, provident fund and gratuity are available.

Candidates meeting requirements for any of the positions may send applications, specifying the post in which they are interested and giving bio-data and full particulars of qualifications, experience, publications, position held and current emoluments to the Manager (Personnel Services), Indian Petrochemicals Corporation Limited, P.O. Petrochemicals, Dist. Vadodara-391 346 Gujarat within 21 days.

Sugar, the wonder molecule

Shiv Pillai, A. Surolia and B.K. Bachhawat

Has sugar molecules in cell membranes come to occupy the place of importance once held by DNA?

IN THE LIFE sciences, as with any other subject of human interest, some areas are considered more fashionable than others at a given time. Carbohydrates held the centre of the stage about half a century ago, but recent decades saw them relegated to the somewhat secondary role of "calorific sources", far removed from the excitement generated by the "super" macromolecules, the highly structured world of DNA helices and superhelices. But, as knowledge increases, frontiers change. No longer are all eyes focussed on the cell nucleus. The cell membrane is the new frontier. Today, this is where the biological show begins.

The membrane plays a crucial role in almost all aspects of cellular activity. A plasma membrane surrounds every cell, whether it is prokaryotic (where the nucleus is not defined) or eukaryotic (nucleus defined). Membranes surround the organelles and other intra-cellular structures like the mitochondria, chloroplasts, lysosomes, endoplasmic reticulum and the nuclei, not to mention the synaptic vesicles, several plant and animal viruses and some bacteriophages(Fig.1).

Membrane constituents

Lipids, proteins and carbohydrates are the major molecular constituents of cell membranes. Of these, lipid molecules are the most abundant although the proteins are much larger molecules. Mass-wise, the carbohydrates, including simple sugars and a variety of derivatives and polymers, are minor constituents. These "sugars" are always found chemically combined with other membrane components: linked to lipids they form glycolipids and with proteins they form glycoproteins. The lipids help maintain the membrane's structural integrity.

The two major kinds of lipids found in membranes are cholesterol and the phospholipids. Cholesterol is exclusively found in the plasma membranes of mammalian cells and is absent in bacteria. But phospholipids are found in all membranes. Intact rod-shaped phospholipid molecules have a "hydrophilic" end, which is attracted to water, and a water-repelling "hydrophobic" end.

These molecules, under certain conditions, lie side by side in sheets in an orderly arrangement. The sheets themselves pair up, with the hydrophobic (non-polar) surfaces facing each other, sequestered away from water. The polar head regions are exposed to the aqueous phases. Such a pair is termed as a bimolecular leaflet (Fig.2). The lipids in each leaflet are in constant motion, but any "flip-flop" from one leaflet to the one on the other side is rare. In this lipid sea float proteins, most of them glycoproteins, which are submerged to varying depths in the lipid bilayer. They are permitted lateral mobility only. Hence, the cell membrane is a dynamic fluid bilayer.

Proteins associated with membranes fall into two classes. The first,

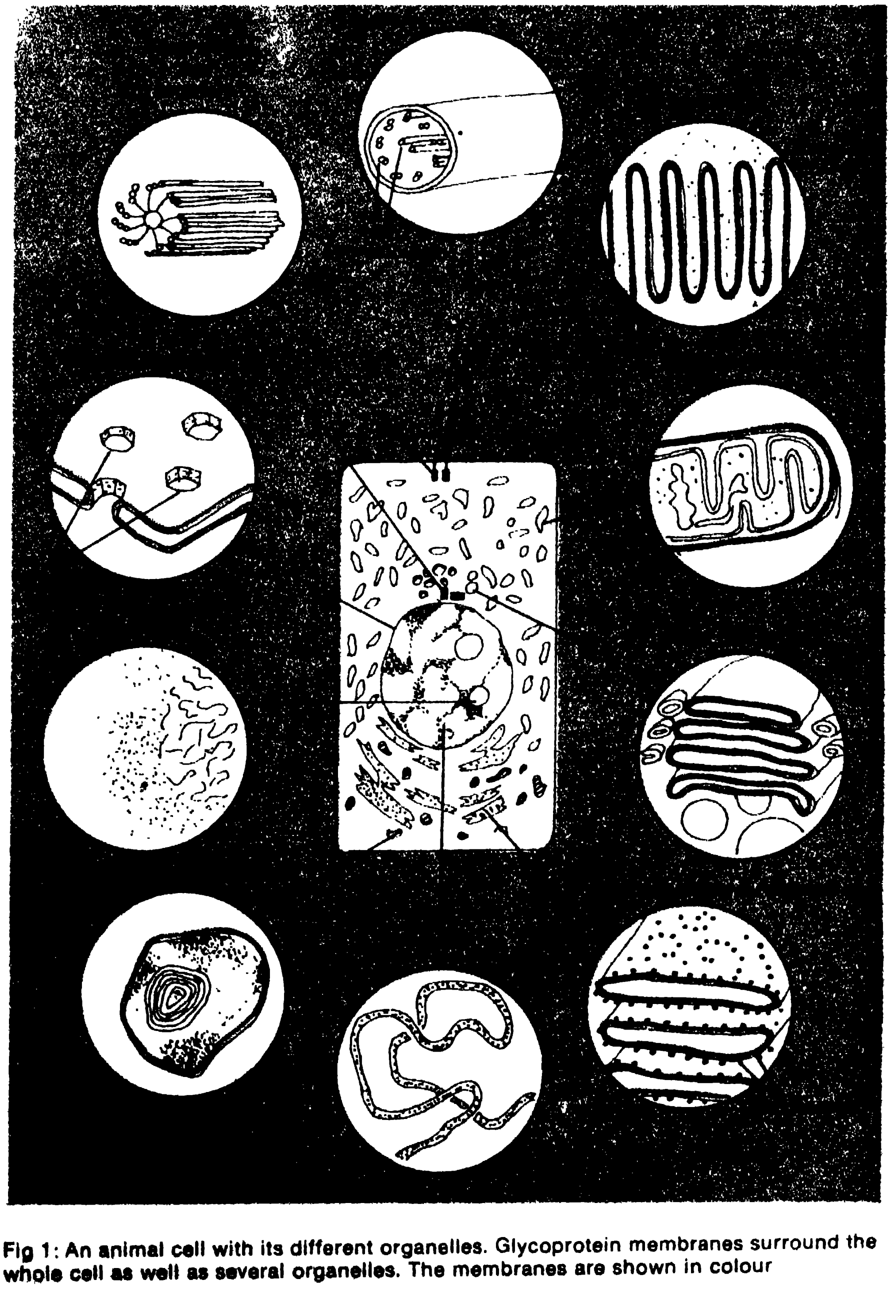

Fig 1: An animal cell with its different organelles. Glycoprotein membranes surround the whole cell as well as several organelles. The membranes are shown in colour

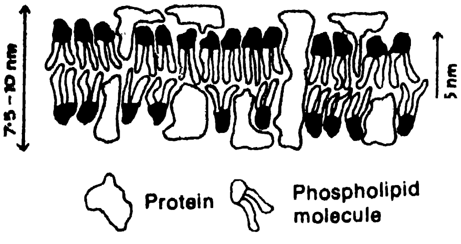

Fig 2. Schematic arrangement of proteins and lipids in membranes. A bilayer of phospholipids forms the structural matrix of a membrane. The lipids are arranged tail-to-tail so that only the hydrophilic heads are exposed to the aqueous medium on both sides of the membrane

integral membrane proteins, those with a portion of each molecule embedded in the lipid bilayer, have regions exposed on both sides of the membrane. The other class consists of peripheral membrane proteins, residing at one surface or the other. Each peripheral protein molecule is bound to an integral protein. The attached carbohydrates invariably reside on the exterior surface, rather than on the cytoplasmic side (Fig.3).

For a cell to survive, its interior must continuously be aware of and respond to external changes. For that, there are some basic functional and structural requirements, like (i) receptors on the cell surface which can sense, both qualitatively and quantitatively, the external environment; (ii) a mechanism whereby a signal is permitted to travel inward across the cell's plasma membrane; and (iii) a system whereby this signal evokes an appropriate internal metabolic change as a response.

The study of how cells carry out these functions is a rapidly burgeoning field. The dynamic nature of the cell membrane is especially suited to serve as the transducer of multifarious signals—hormonal, immunological, sociological and others—which influence the differentiation, division and specialisation of cell function.

All membrane recognition processes—in fact all biological processes—can be reduced to the mechanics of stereochemistry (which is a study of the spatial arrangements of atoms in molecules and the chemical and physical consequences of such an arrangement). With today's understanding, the seemingly colourless sugar molecule is seen as a remarkably versatile stereochemical unit capable of creating a wide range of three-dimensional configurations. With simple calculations, the number of different stereochemical structures that three sugars in covalent continuity can create is 1056, while the corresponding figure for three different amino acids is only six.

Further, it would seem a good bet if one were to look for the basic stereochemical unit responsible for cellular identity and recognition in the covalently attached oligosaccharide side chains (sugar molecules) of glycolipids and glycoproteins (collectively called "glycoconjugates") or in the different sugar groups or its residues attached to the lipids and the proteins of the membrane.

Proceeding on the hypothesis that the stereochemical diversity of the plasma membrane resides in these sugar molecules, we discuss their functions in glycoconjugates.

Is there a general role for the sugar moieties of the membrane glycoproteins? And, could the role of the sugar be non-specific? In attempting to answer these questions, it is probably worthwhile to take a look at certain well-characterised membrane glycoproteins of "known" functions. In prokaryotic cells, five membrane transport systems have been isolated and well characterised. Each of these consists of oligomeric (having several sub-units) glycoproteins which span the bilayer and transport solutes by undergoing small conformational changes. The need for an oligomeric arrangement may be because the active site for transport is produced at the interface between subunits, or because allosteric control is more easily realised in oligomeric proteins. The oligosaccharide side chain does not appear to be involved in the binding of the transport solute. Perhaps the sugar side chains serve to fix the transmembrane arrangement of these glycoproteins. As for some membrane proteins, a receptor or recognition role for the sugar seems likely.

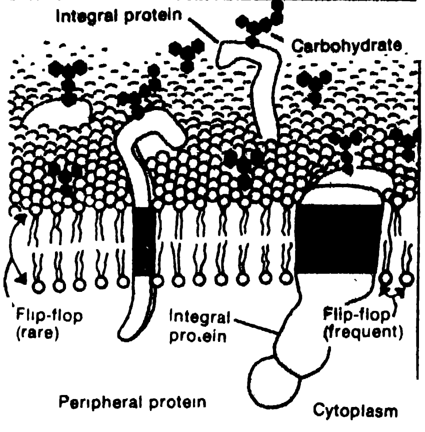

Fig 3: Model of the plasma membrane includes proteins, carbohydrates and lipids. Integral proteins are embedded in the lipid bilayer; peripheral proteins are merely associated with the membrane surface. Carbohydrates consist of monosaccharides, or simple sugars, strung together in chains that are attached to proteins (forming glycoproteins) or to lipids (forming glycolipids). The symmetry of the membrane is manifested in many ways. Carbohydrates are always on the exterior surface while peripheral proteins are almost always on the cytoplasmic or inner surface. Each species of integral protein has a definite orientation, which is the same for every molecule of that species

But has the sugar a receptor role or does it act as a hydrophilic plug? If it were merely a plug, why then does stereochemical variety occur in the oligosaccharide side chains of different glycoproteins? And, are there subtle variations in the orientations of different glycoproteins which require these differing oligosaccharide side chains?

Cell-cell and cell-ligand interactions

It is in cell sociology—the interaction of cells with one another—that the structural variety of the sugar molecules has provoked the greatest interest. Here, the term ligand refers to the binding molecules that are themselves not structural components of any cell membrane. The fundamental similarity between cell-cell and cell-ligand interactions as far as their stereochemistry and binding characteristics are concerned is obvious. They will, therefore, be discussed together.

Carbohydrate-carbohydrate interactions. One would imagine that the interaction of carbohydrate with carbohydrate would be providing the greatest range of "lock-and-key" arrangements for cellular interaction. However, the general assumption is that sugar residues on cell surfaces are strongly solvated by water. This has led to doubts regarding the possibility of strong, specific stereochemical interactions occurring between saccharide residues.

Very few examples of important sugar-sugar interactions in cell sociology have so far been noted. One example of what is possibly a sugar-sugar interaction mediated by glycoconjugates is the aggregation of certain sea sponges. It is known that different species of sponges release specific soluble aggregation factors (known to be glycoproteins) which cause sponge cells of the same species to stick together. In the case of the sponge *Microciona prolifera,* it has clearly been shown that the glucuronic acid residues of the glycoprotein factor is made up of subunits stabilised by calcium ions. A model for the cell-cell interaction of these sponges is depicted in Fig.4. However, the structure of the membrane component which binds to the aggregation factor has not been completely established.

The fact that the binding activity of this membrane component is lost following mild chemical treatment which destroys sugar residues suggests that the receptor may be a glycoconjugate whose sugar residues are involved in its binding activity. If this somewhat tenuous evidence is confirmed by structural studies, this sponge aggregation phenomenon may perhaps be the only documented example of sugar-sugar interactions involving cell surface glycoconjugates.

Sugar-sugar interactions between polysaccharides have led to the realisation that the shapes of carbohydrates can be as exciting as those of proteins and nucleic acids. Perhaps the best defined study of sugar-sugar interactions in cell biology has emerged from work on the extracellular polysaccharides of the *Xanthomonas* species (pathogens responsible for blight disease in a number of crop plants). The cellulose-like structure of these polysaccharides may well be the molecular 'glue' attaching the pathogen to the host's cell-wall.

Carbohydrate-protein interactions are the most widely studied of the interactions. The ability of specialised proteins (such as antibodies and enzymes) to stereospecifically recognise and bind to certain molecules has been of interest for the last few decades. But it is only in recent years that a lot of excitement has been generated by the lectins—proteins that can unite or agglutinate erythrocytes and other cell-types. They are widely distributed in different plant tissues and also in invertebrates and lower vertebrates. These proteins have two or more binding sites for specific sugars or for specific oligosaccharides or even for specific glycopeptides. The best studied lectins have plant sources, although little is known of their biological role in plants. In recent years, the discovery of cell surface lectins from various sources has thrown some light on the possible functions of some of these molecules.

Slime moulds present very interesting models of cell sociology and cell aggregation. There are two distinct phases in the lifecycle of the cellular slime mould *Dictyostelium discoideum:* a non-social vegetative phase in which the separate organisms feed on bacteria and divide by fission, and a social phase initiated by a period of starvation in which the free living moulds aggregate to form a multicellular structure before the formation of the fruiting body. Developmentally regulated lectin activity on the surface of these cells has been demonstrated successfully. The appearance of the lectin activity coincides with the development of cohesiveness by these cells. Two lectins—Discoidin I and II—have been isolated from these cells.

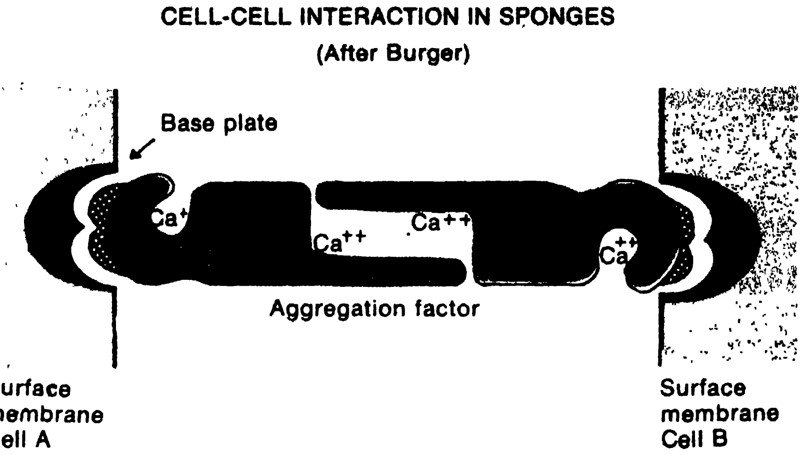

Fig 4: Specific soluble aggregation factors, which are sugar residues of the glycoconjugates, are released by different species of sponges. These factors cause sponge cells of the same species to stick together. Calcium ions stabilise the aggregation factors

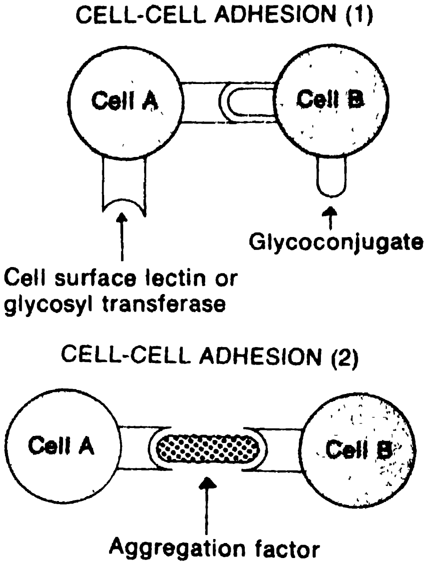

Fig 5: Different theories are put forward to explain cell-cell adhesion. In (1), the binding of a cell-surface lectin or a glycosyl transferase and a glycoconjugate leads to a lock-and-key sort of binding. In (2), aggregation factors bring about the binding

A similar pair of developmentally associated lectins have been isolated from another mould (*P. pallidum*) too. More recently, a developmentally regulated lectin activity in neonatal rat brain has also been detected.

Studies initially at the Neurochemistry Laboratory, Vellore, and later at the Indian Institute of Experimental Medicine, Calcutta, have demonstrated that the interaction involving lectins and glycoproteins consists of two phases. The initial sugar-protein recognition is stabilised by secondary protein-protein interactions. Similar two-phase association of cells has also been demonstrated. Also, chick embryonal cells and neural retinal cells initially bind together in a loose, reversible form. This loose binding suggests a role in "testing" the correctness of a cell-cell association before stable intracellular bonds are formed. Similar two-step processes have also been described for slime moulds as well as for macrophages.

An interesting hypothesis for protein-carbohydrate linkages in the association of cells was that cells bind to each other through the non-covalent attachment of surface enzymes (glycosyl transferases) to glycoprotein or glycolipid acceptor molecules. Although this hypothesis has been found extremely attractive because the specificity shown by these enzymes towards their acceptors is extremely high, it has not so far been universally accepted (Fig.5-1).

Evidence supporting the concept that the oligosaccharide residues of certain gangliosides (a type of lipid commonly isolated from nerve or spleen tissues) serve as receptors for various proteins of biological importance is fast accumulating, especially in the case of certain hormones. Fluorescence studies have clearly revealed a distinct change in the shape of the hormone molecule following its interaction with gangliosides, and there was a progression from "non-inhibitory conformation" to an "inhibitory conformation" which exactly paralleled the ability of gangliosides to inhibit hormone binding. Also, the binding of interferon—an antiviral glycoprotein—to a type of ganglioside on the cell surface appears to be a carbohydrate-protein interaction. Very little is yet understood how these gangliosides are disposed of on the membrane—whether in clusters or randomly—and about their mode of function.

Role of sugar in extracellular glycoproteins

Some proteins with sugar groups (glycosylated) are found unattached to the plasma membranes of their cells of origin—for instance, the serum proteins (except albumin and pre-albumin) and some hormones, components of the connective tissues and certain secretions of the gut and the respiratory tract. Each of these "extracellular" proteins was intracellular prior to being secreted and shed away.

The "physico-chemical" functions of some of these glycoproteins are distinctly attributed to the presence of sugars. The role of sialic acids (acylated aminosugar acids) in increasing the viscosity of mucins (glycoproteins which line the mucus membranes) is well known. To quote a few instances, these glycoproteins protect the digestive tract from injury and autodigestion. Their flow along the respiratory tract helps keep the lungs sterile. Besides, they moisten and protect the cornea and lubricate the eyeball during its rotatory movements. Mucins in the vagina have a lubricatory role in childbirth and coitus; the cervical plug of mucus keeps the uterus, and consequently the abdominal cavity, sterile. The removal of the terminal sialic acids from these mucins leads to a striking fall in their viscosity.

The antifreeze glycoproteins are a unique family of proteins found in the sera of several Antarctic fish (see Science Today, August 1976, p 57). They range in sizes from 11,000 to 32,000 daltons and appear to protect these fish from freezing in subzero temperatures. These glycoproteins have the unique property of inhibiting the phase transition of water to ice. The antifreeze character of these glycoproteins is lost on modification of the sugars by chemical processes. The hydroxyl groups on positions 3 and 4 of the galactose residues are probably involved in the biological function.

The role of sugar, which is present on the surface of "extracellular" glycoproteins, as a passport for the secretion of these glycoproteins from the cell commands attention. But then, quite a few extracellular proteins are not glycoproteins, for example albumin and pre-albumin amongst the serum proteins, and prolactin, somatotropin and adrenocortico tropic (ACTH) amongst the anterior pituitary hormones. At the same time, there could be more than one mechanism involved in the secretion of proteins.

Three stages in the life-cycle of a protein are to be considered while studying the biological role of the sugar side-chains of "extracellular" glycoproteins. The first stage is the secretion process; the second is the period in which the known biological function of the protein is served in its extracellular milieu, and in the third stage a role is played by the sugar in the clearance and catabolism of the glycoprotein.

Few roles other than the physico-chemical" for the sugar side chains of extracellular glycoproteins have so far been discovered. For most glycoprotein hormones, the sugar moieties do not seem to be involved in either the binding of these hormones or their triggering of target cells. A possible exception is human chorionic gonadotropin (HCG) From the Neurochemistry Laboratory at Vellore came the first report that the sugar side chains of a glycoprotein enzyme did not play a role in its catalytic function. In fact, for several known intra- and extracellular glycoproteins, the sugar side chains have almost universally been found not to play a catalytic role. A probable exception is glucamylase I of *Aspergillus niger*. But, it is in the clearance and survival of circulating glycoproteins that some of the most exciting discoveries regarding the role of the sugars in extracellular glycoproteins have been made.

It has been convincingly demonstrated that many serum glycoproteins are recognised and cleared from the circulation by a galactose binding receptor present on the plasma membranes of hepatic parenchymal cells. The terminal sugar on most serum glycoprotein side-chains is sialic acid and the preterminal sugar, usually a galactose. The galactose-recognising receptor on the hepatic parenchymal cells has been isolated. This is the first mammalian lectin to have been discovered. Lectins are bi- or multi-valent carbohydrate-binding proteins, originally found in plants. The hepatic lectin is a glycoprotein which must itself be sialated in order to recognise desialated proteins. Calcium ions are necessary for the activity of this receptor.

It is interesting to note that, just as the hepatic parenchymal cell recognises desialo-glycoproteins, the kidney has been shown to be the site of removal from the plasma of certain glycoproteins. The receptor involved in this phenomenon has not yet been characterised.

Glycoproteins are also known to be receptors for certain proteins. The receptor for insulin in liver and fat cells is a membrane glycoprotein. The preterminal galactose residues of this glycoprotein have been shown to be vital for its insulin-binding activity. The surface receptor for the pituitary hormone, ACTH, also appears to be a glycoprotein, the terminal sialic acid residues playing a role in hormone binding. The receptors on macrophages also appear to be glycoproteins.

The work on I-cell disease (where a particular enzyme system is non-functional) has led to the suggestion that the sugar residues of enzymes, lysosomal acid hydrolases, are involved in the uptake of these enzymes by cells. Apparently, when these enzymes are released into the extracellular milieu, following cell death or in other physiological circumstances, their sugar residues are recognised by cell surface receptors. These enzymes

ROSEMAN'S HYPOTHESIS

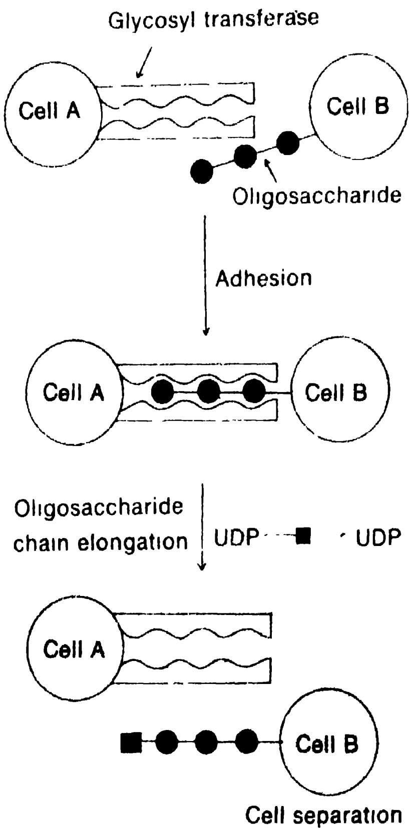

Fig 6· Roseman's hypothesis for the association of cells. Cells are believed to attach to each other through non-covalent attachment of surface enzymes to the glycoprotein or glycolipid (oligosaccharide) acceptor molecule. A specific sugar nucleotide is then divested of its sugar which is used to lengthen the acceptor oligosaccharide chain. The specificity shown by these enzymes towards the acceptor molecules is very high

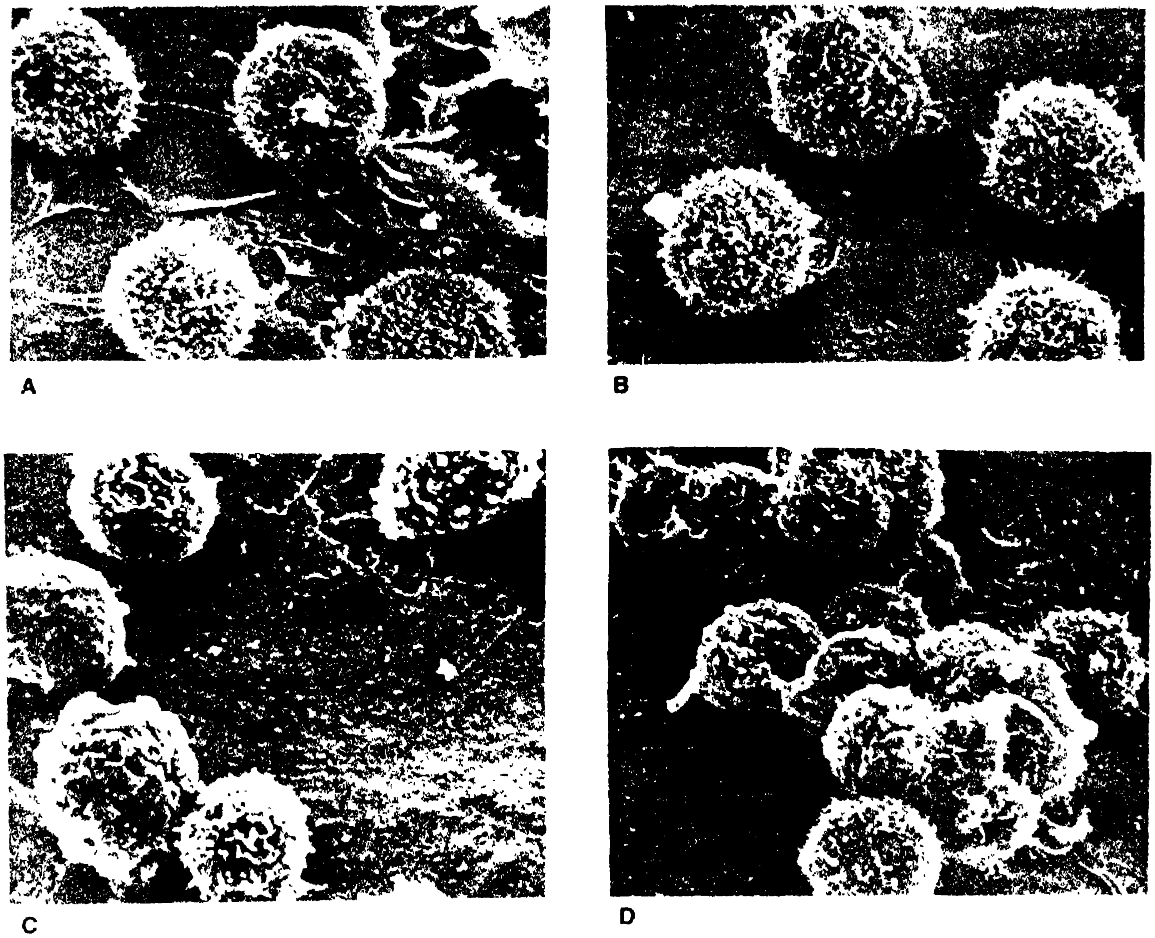

Fig 7 Scanning electron micrographs showing the effect of a lectin on normal mouse fibroblast cells and on malignantly transformed cells Normal cells (A) are not agglutinated (B) when the cells are treated with the lectin concanavalin A But when malignantly transformed cells (C) are treated with lectins, agglutination occurs (D). Cells shown enlarged 1,800 times

are then endocytosed (that is, extracellular materials are introduced into the cytoplasm) and returned to the lysosomal milieu containing a battery of digestive enzymes. In I-cell disease it appears that this enzyme "recycling" process is lost.

Many interesting hypotheses for cell-cell interaction in biological processes in which sugar-protein or sugar-sugar interactions play a part, have been postulated. An interesting one concerns the connections between the retina and the tectum (the roof-like structure of the mid-brain) which exhibit a very exacting point-to-point accuracy. It has been suggested that sugars must play a role in the specificity of these connections and the existence of diffusion gradients for sugar residues in glycoconjugates at corresponding areas of the retina and tectum has been postulated.

The detection of small quantities of glycoproteins in myelin (the fatty sheath surrounding certain nerve fibres) has given rise to much speculation regarding the role of sugar molecules in the myelination process too.

The body's immune system is concerned with recognising and destroying the invader cells. The first target of the immune system when it comes across an invader is its membrane; it has to poke bores or holes into the membrane. Secondly, it has to assume that a particular membrane is a target worthy of attack and not an innocuous membrane best left alone. When foreign material, be it large molecules, bacteria or viruses—all operationally defined as antigens—is introduced, the immune system goes into action in two ways. It makes a special class of proteins called antibodies and also produces sensitised cells, both of which fit the antigen just as a key fits a lock. This binding (antigen-antibody/sensitised cell) initiates a series of reactions that contribute to the destruction of the antigen or its elimination from the body.

Every blood group has a specific structure that is a part of one of the many different blood group antigens. The inheritance of each antigen is genetically controlled. There is one gene for each antigen, each antigen being a complex serologic entity. A blood group antigen has different sites, each of which reacts with a specific blood group antibody. About 200 of these sites have been identified and each is a separate blood group.

It is well known that many antigens of clinical importance have been shown to have oligosaccharide sequences. The best known examples are perhaps the antigen molecule that determines the specificity of antigen-antibody reaction of many gram-negative bacteria, the pneumococcal polysaccharides and the antigen of the ABH, Lewis and MH blood group systems. The sugar sequences responsible for the differences between these blood groups have been well worked out, and even the genetics of these differences are fairly well understood. The antigenic sugars, responsible for ABH antigenicity, are believed to be present on the red cell surface of glycolipids and on glycoproteins of the secretions (body fluids) of individuals, known as secretors. Recent evidence indicates that erythrocyte membranes contain glycoproteins carrying the relevant ABH oligosaccharides. It is possible, therefore, that both glycolipids and glycoproteins carry the sugars which are the determinants of ABH blood group on red cell surfaces.

The A, B, H and Lewis blood substances are macromolecules, with highly specific, serologically active antigenic sites. The water-soluble forms in body fluid are glycoproteins while those of red cells are glycolipids. The polysaccharide portion of the molecule is responsible for serologic specificity and is constructed from five sugars: D-galactose, L-fucose, N-acetyl-glucosamine, N-acetyl-D-galactosamine and N-acetylneuraminic acid. The polysaccharide portion of the blood group molecules is the same for identical blood group antigens, whether in body fluids or on the erythrocyte membrane.

Although the importance of these antigens in the genetic delineation of individuals and in tissue rejection is appreciated, the biological function of these oligosaccharide determinants is poorly understood. The fact that apparently normal individuals who do not carry any of the ABH determinants (people of the rare "Bombay" blood group) have been found, argues against any role of these sugar determinants in cell vitality. It is interesting to note that human ABH substances, apart from being found on erythrocytes and (in higher concentration) in the epithelial secretions of secretors, have also been found to be present in over half of some 300 species of gram-negative organisms in the same or closely related chemical form. The actual function of the blood group substance in man remains a mystery. The fact that they are highly antigenic may be coincidental.

It was speculated by the authors in the early 1960s that the carbohydrate sequences of the blood group antigens might perhaps be found in other glycoconjugates of the same individual, since the same genetic central mechanism operates. Subsequently, glycoproteins studied have been found to have different sugar sequences, although related to the blood group antigens.

The ability of the immune system to mount responses against self tissues even in "normal" individuals is well documented. In this context an interesting hypothesis for the maintenance of "auto-tolerance" (no antibody production against one's own antigens) has been suggested. The glycoproteins which are being shed from the surfaces of all the cells in the body are considered to be responsible for exerting a state of immune paralysis in the respective lymphocytes (Fig.8).

Sugar in immunoglobulins and alpha foetoprotein

Heterogeneity in the types of molecules that can function as antibodies has long been recognised. These molecules differ in their physical, chemical or antigenic properties, but retain the functional integrity of an antibody. These subgroups (5 major classes) of antibody molecules are called immunoglobulins.

The Ashwell-Morell hypothesis for the clearance of glycoproteins had led to very interesting speculations on the role of sugar in antibodies. The half-life (period for starting concentration to go down by one-half) of certain glycoproteins in the circulation is based on both the probability that the glycoprotein will contact the enzyme sialidase and the subsequent cleavage of the glycoprotein's terminal sialic acid. The significance of this "ageing" or "decaying" process on antibody half-life has been highly speculated upon. It is believed that antibodies with relatively more sialic acid are molecules that persist longest in the body.

Alpha foetoprotein (AFP) is the dominant serum protein in early embryonic life. Although it is a glycoprotein, its polypeptide portion has been shown to possess some structural similarities to albumin. The AFP and albumin levels in any stage of ontogeny are known to be inversely proportional to each other. AFP is also considered to be a tumour-associated antigen because it appears in the sera of patients and animals with primary liver cancer. The function of AFP in the foetus remains unknown, though an immunoregulatory role for AFP has been suggested. It was demonstrated that mouse AFP has an immunosuppressive effect on antibody synthesis, both *in vivo* and *in vitro*. Human AFP has also been shown to have immunosuppressive properties. A heterogenous structure is attributed to mouse AFP, consisting of five components designed FP_1...FP_5, which differ in their sialic acid content. FP_1 has no sialic acid and exhibits no immunosuppression *in vitro*, while FP_5 has four sialyl residues and exhibits the greatest immunosuppressive effect. Thus, the AFP molecule is essential for the immunosuppressive properties of this glycoprotein, both *in vivo* and *in vitro*.

Lymphocyte homing and stimulation

Lymphocytes, the cells responsible for immune reactions, develop from stem cells in the bone marrow. These cells circulate in the body in a unique way and they eventually "home" to lymphoid tissues. The very "homing" patterns, or the wandering of lymphocytes, may also depend on the surface glycoproteins of lymph nodes. Alteration in them may modify their homing pattern. They appear to recognise certain glycoprotein receptors on the walls of the lymph nodes. Again, sialic acid appears to be necessary in the recognition phenomenon.

Lymphocytes have on their surface a variety of glycoproteins, many of which are antigenically and chem-

Trypanosome parasites change their coats!

There are oceans of evidence documenting the development of neoantigens (antigens different in form from the original) in transformed or virally infected cells. Many of these changes are due to the synthesis of altered glycoconjugates, or of different proportions of membrane glycoconjugates as compared to normal cells. Hence, strictly, a "role" for the oligosaccharide moieties of glycoconjugates in this phenomenon is unlikely.

Antigenic variation is a phenomenon associated with the salivary trypanosome infections of man and animals in Africa. Each succeeding *Trypanosome* population is characterised by a specific variant glycoprotein antigen present in the parasite surface coat. Since this changed antigen does not react with antibodies already induced against previous specific antigens, it may as well be termed an immunological deception phenomenon. It is the major cause of fatality from *Trypanosome* infections.

Sialic acids seem to exert a peculiar negative role in masking the surface antigens of certain cell membranes. Tumour-specific antigens, for example, those on tumour cell surfaces, seem to be masked by sialic acid residues. Removal of sialic acid increases the immunogenicity of the normal as well as tumour cells. Therefore, sialic acids may directly be a part of the antigenic determinants in some cases.

Interestingly, there are antigenic similarities between the membranes of many viruses and the host cells in which they grow. It is possible that the carbohydrate units of the virus membrane are specified by the enzymes (glycosyl transferases) of the specific host cell. The virus is thus able to escape the immunological response of the host animal, incorporating the heterosaccharide structure of the host using the enzymes of the latter only. This simplifies its task considerably, as the normal array of enzymes (glycosyl transferases) needed would not be coded by the small genome of these viruses.

ically well defined. When a lymphocyte is stimulated by a lectin (or by specific antigens), dynamic changes occur on the lymphocyte surface. Initially, the receptor molecules for the lectin are randomly distributed over the entire cell surface. After the interaction of the cell with the lectin, redistribution of the receptor sites occurs, forming concentrated clusters or patches of receptor ligand complexes. Here individual glycoproteins may be clustered independently by specific ligands. Apparently, there are some physical interactions between different species of glycoproteins such that perturbation of the distribution of one of them also influences the display of the second.

Saccharophilic look

This article has an obvious "saccharophilic" bias, which will perhaps be justified in the coming decades. And, it is likely that only the surface of the sugar story has been scratched. Finer analytical techniques, especially in cell and membrane biology, will be necessary to probe deeper into the roles of the sugar moieties of the glycoconjugates. It could well be that more information is stored in the oligosaccharide side chains than has hitherto been imagined. The possibilities are endless.

In the near future, membrane oligosaccharides may play a pivotal role in medicine, especially in tissue-specific therapy. By virtue of the sugar-specific receptors present on the surfaces of certain tissues, specific target drugs and other therapeutic agents may be targeted to these tissues. In therapeutic practice, the ability to target pharmacological agents to their intended sites of action is an ideal situation. The question of side, effects would not arise and large, effective doses would be safely administered. The use of cell surface sugars and sugar receptors would be an elegant means of subverting nature's recognition methods to mankind's ends.

Prof Bachhawat, Director, Indian Institute of Experimental Medicine (IIEM), Calcutta, has been doing significant work on glycoconjugates for the last 20 years His laboratory was the first to show the primary enzyme defect of amyl sulphatase in sphingolipidosis (a hereditary metabolic disorder) He received the Shanti Swarup Bhatnagar Prize in 1964

Dr. Surolia, a biochemist at the IIEM, has been studying, among other things, functions of proteins and protein-carbohydrate interactions

Dr Pillai, at present with the Kothari Centre for Gastroenterology, Calcutta, is a medical graduate whose research interests include high-sensitive immunoassay for peptide hormones and affinity crosslinking for the 3-D structure of non-crystalline proteins.

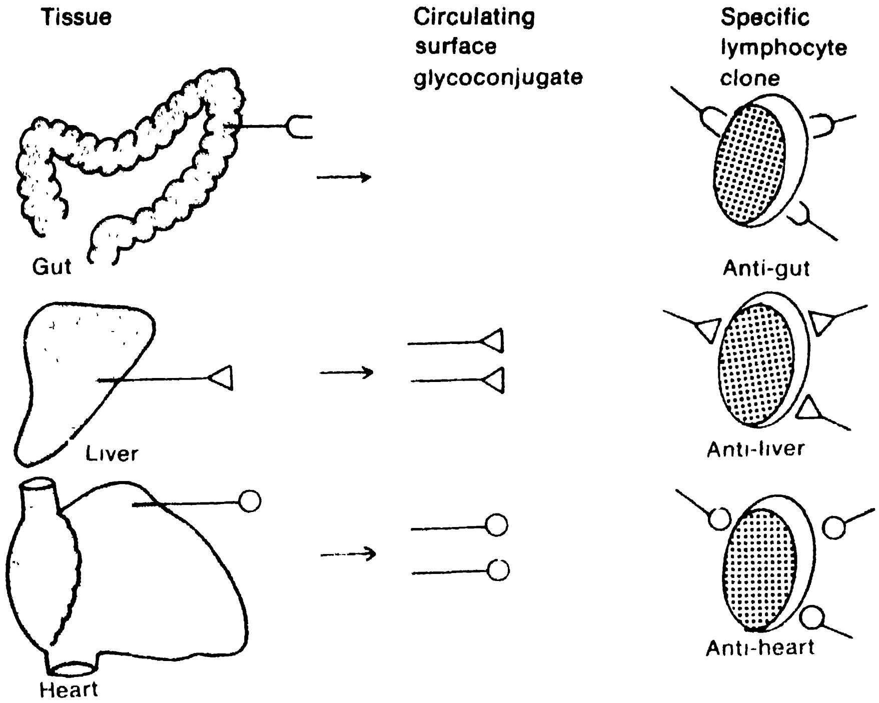

Fig 8 Autotolerance maintenance — why no antibodies are produced against one's own antigens The glycoproteins which are continuously being shed from the surface of all cells are responsible for immune paralysis of the lymphocyte populations

Glycoconjugate therapy

A RECENT report in *Nature* (**282** 73) has evoked further interest in the *Trypanosoma cruzi* which is the causative factor for the debilitating Chagas' disease in man. So far, there is no suitable chemotherapy for the disease and even the use of vaccines is hindered. This is because of the possible existence of antigens in *T. cruzi* and the subsequent induction of autoimmunity. These antigens stimulate immunity against mammalian heart and nervous tissue, which further results in cardiac and neural lesions. Hence, vaccines prepared from the whole organism (either killed or attenuated) might perhaps induce symptoms of the disease. Recently, it was found that mice were protected effectively against an acute infection of *T. cruzi* when they were vaccinated with a particular glycoprotein in combination with certain adjuvants.

An integral membrane glycoprotein has been isolated from the cell surface of *T. cruzi*. This major glycoprotein has some very characteristic properties of being present throughout the life cycle of the parasite and not undergoing any antigenic variation. Different adjuvants like Freund's complete adjuvant or saponin were used in conjunction with the above glycoprotein in the preparation of an effective vaccine. Results obtained are tabulated below.

These results suggest that the glycoprotein could be an effective candidate antigen for a vaccine against American trypanosomiasis. Immunisation with glycoprotein alone was partially protective, as indicated by low blood parasite levels and slightly prolonged survival times. Further research would reveal whether adjuvant additions are absolute for optimal immunisation. Also, more clinically acceptable adjuvants would be necessary.

B.S.M.

Nature of treatment (immunisation)	Blood parasitaemia level	MST days
Unimmunised mice	High	24.2
Immunisation with Freund's complete adjuvant alone	High	25.2
Saponin alone	High parasitaemia	24.2
Glycoprotein alone	Delayed parasitaemia	31.2
Glycoprotein + Freund's adjuvant	Low parasitaemia or nil	Indefinite survival
Glycoprotein + Saponin	Low parasitaemia or nil	Indefinite survival

From Alchemy to to-day's Science

Alchemy began by an obsessive urge for transforming the baser metals into gold. The alchemists never succeeded in making gold from base metals, yet their experiments recorded under mystic terminology, gradually led to the discovery of metallic arsenic, antimony and phosphorus.

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Interferon interactions

A WELL-DEVELOPED immune system is perhaps the greatest endowment nature has conferred upon mammals in general, and humans in particular. Further, the discovery by a group of British researchers in 1957 of 'interferons' was hailed far and wide, because it was thought they could provide the much-needed weapon against viral attacks. Interferons are glycoproteins with antiproliferative and antiviral activities but, from the beginning, interferon studies had yielded conflicting results. Also, despite convincing evidence about its efficacy in the murine system, its utility in humans could not be demonstrated unequivocally. This was partly because of paucity of human interferon and partly because of the lack of adequate information about its mode of action

Over the years its physical, chemical and biological properties have been studied more extensively Now J.R Huddlestone, J C. Merigan Jr and M B A. Oldstone (*Nature* **282** 417) of the Stripps Clinic, La Jolla, California, USA, report that interferon induces the generation of natural killer (NK) lymphocytes capable of lysing virus-infected and malignant cells These are non-T, non-B lymphocytes in contrast to two distinct sub-populations of lymphocytes, thymus-derived or thymus-dependent T-cells and thymus-independent B-cells. They found that daily injections of human leucocyte-derived interferon for about a month resulted in the activation of NK cells in all the five patients suffering from non-Hodgkins lymphoma, a malignancy of the lymphoid organs. Although there were individual differences in the kinetics of development and decline of the NK activity, it consistently stayed above the pre-interferon therapy level in all the patients. More interestingly, none of them showed any extension of lymphoma even though the usual chemotherapy was not introduced. In some cases even remission of the disease occurred without any relapse.

Human interferon, this time from the fibroblasts, was also employed by J.H. Horoszewicz, S.S. Leong and W.A. Carter, of the Roswell Park Memorial Institute of New York (*Science* **206** 1091). Their studies, however, were conducted *in vitro*. The target cells in the culture system were Daudi cells derived from Benkitt's lymphoma which mainly afflicts black Africans.

These studies have provided yet another interesting clue on the way in which interferon exerts its antiproliferative activity. While in culture, the seeded cells are initially in the resting phase. As they spend more time in the nutrient medium, a few cells start dividing initially. This process gains momentum finally resulting in a logarithmic increase in their number. Horoszewicz and his colleagues found that if interferon was introduced in the culture while the cells were still in the resting phase, it brought about a drastic reduction in the number of cells which divided later on However, this antiproliferative activity was minimal if interferon was made available after the cells had reached the logarithmic phase of growth Significantly, the effect could be triggered by short exposures to interferon. Clinicians involved in cancer management regularly used drugs which impair the cell-cycling activity, causing an enrichment in the proportion of resting cells Interferon, in combination with such drugs, can mount a two-pronged attack on the malignancies

These studies gain considerable significance because of three important points. Foremost among these is the convincing demonstration in both the cases of the effectiveness of human interferon in systems of immediate clinical interest. Both the groups have used malignancies as the targets in clinical use Secondly, the observation that interferon induces NK activity implies not only that it acts through a mediator but also that it need not be directly accessible to the infected or malignant cell Further, through the NK cells its effectiveness could be amplified The third point is that even a brief exposure to small quantities of interferon can produce the desired effect It should offset to a great extent the restraints on further research and clinical use imposed by short supplies of this agent.

A major impediment to routine clinical use of interferon is its high cost. Also, it is not available in large amounts at present. Perhaps the newly developing technology of hybridomas could bridge the technological gap. But the key to the clinical success of interferon probably lies in the unravelling of its amino-acid structure and subsequent synthesis using the cloning technique employed in the manufacture of somatostatin or insulin. Even for this, very pure preparations of interferon would be needed initially. The recent communication of M. Rubinstein and his colleagues (*Proceedings of National Academy of Sciences*, USA **76** 640), describing production of pure homogeneous human interferon and its partial characterisation, should facilitate this.

G.P. PHONDKE

Dr. Phondke is the Head, RBDH Section, Medical Division, BARC, Bombay.

Measuring nuclear lifetimes

THE RELEVANT time-scales in nuclear physics cover a wide range of values. On one end of the scale we have radioactive nuclei with lifetimes in the range of a billion years ($\backsim 10^{16}$ sec), on the other are the reaction times between two nuclei which could be as short as 10^{-22} sec Although, over the years, numerous ingenious experiments have been devised to measure short lifetimes, measurement of very small ones of the order of 10^{-15} sec and lower, have been only recently accomplished. This range of nuclear lifetimes is encountered among nuclei in highly excited states. Excited state means an energy level which is higher than the lowest, the ground state of the nucleus.

An undisturbed nucleus is in its ground state. Only when it is disturbed through a force does it go into an excited state. But a nucleus can be excited only to discrete states, and even then it would eventually decay back to the ground state. In other words, an excited state would have a lifetime. It is the measurement of these lifetimes that gives vital information on the reaction processes

Recently, a team of researchers from the University of Koln, West Germany, reported measurements of nuclear lifetimes in the range of 10^{-17} sec (*Physical Review Letters* **43** 1300). They used an effect which, though known in principle for over two decades, has found practical applications only in recent years due to improved detection techniques. The effect is as follows during a nuclear reaction, or during beta or alpha decay of a radioactive nucleus, there is a small but finite probability that an electron from the most tightly bound atomic shell (called the K-shell) may be knocked out leaving a vacancy. When this happens, an electron from the next higher shell would jump to fill the vacancy in the K-shell and, in the process, emit an X-ray which is characteristic of the atomic (or proton) number of the nucleus

Now consider the case of a proton (p) bombarding the nuclei of tin (Sn) and forming a compound system, p+Sn, which is the element antimony (Sb) in an excited state Let this state of antimony have a lifetime, T, after which it decays into a proton and tin nucleus. During this process, a vacancy in the K-shell has also been produced for some of the events We have then two options for these events: (1) the compound system may first emit an X-ray, which would be characteristic of antimony, and then break up into a proton and tin nucleus, or (2) the compound system first breaks up into a proton and tin nucleus and an X-ray characteristic of tin is emitted subsequently. This can be represented as:

$$1)\ p + \mathrm{Sn} \longrightarrow \underset{\leadsto\ \text{X-ray}}{\mathrm{Sb}} \dashrightarrow p + \mathrm{Sn}$$

$$2)\ p + Sn \longrightarrow Sb \longrightarrow p + Sn$$

X-ray

Since the lifetimes for X-ray emission from atomic shells are now accurately known, by comparing the number of X-rays emitted for either case the lifetime of the nuclear excited state can be determined. If N_1 and N_2 are the number of X-rays in cases 1 and 2, respectively, and T_K and T_N denote the X-ray and nuclear lifetimes, respectively, then

$$N_1 / (N_1 + N_2) = T_K^{-1} / (T_K^{-1} + T_N^{-1})$$

The scientists at University of Köln obtained for the nucleus ^{113}Sb, lifetimes of 4×10^{-17} sec at an excitation of 15 MeV

AMIT ROY

Dr. Roy is with the Nuclear Reaction Group at the Tata Institute of Fundamental Research, Bombay

Breakthrough in programming

A RUSSIAN mathematician, L. C Khachian of the Computer Centre of the USSR Academy of Sciences, has made a major breakthrough in solving certain kinds of linear programming problems. The important implication of his paper (*Proceedings of the USSR Academy of Sciences* (DAN) **244**, 1093) is that it could lead to a considerable saving in computation time if used instead of the conventional simplex method.

The simplex method, which was developed by George Dantzig of Stanford University in 1947 and has been modified several times since then, currently has many business, economics, and industrial engineering applications. Consider the following simple example on the use of the simplex method in linear programming

A carpenter makes chairs and tables It costs him Rs. 250 to make a table and Rs 50 to make a chair. He can invest up to Rs. 6,000 per month and he has a storage capacity of 60 units. He is able to sell a table at Rs. 300 a piece and a chair at Rs. 65 a piece. Assuming that he is able to sell all the chairs and tables he makes, how many of each should he make to maximise his profit? Translated mathematically, this means that if he produces x tables and y chairs, $250x + 50y \le 6000$, or $5x + y \le 120$; $x + y \le 60$, $x \ge 0$, $y \ge 0$ and his profit is $P = 50x + 15y$. To solve this problem all that the carpenter has to do is to take a graph paper, draw the lines $5x + y = 120$, $x + y = 60$ and observe that he could make tables and chairs corresponding to points in the shaded region and for each such choice his profit is $P = 50x + 15y$ (Fig. 1). To obtain the maximum profit he has to see which of the parallel lines, $50x + 15y = P$, is farthest away from the origin and yet meets the shaded region. He would soon be convinced that the line he is looking for would pass through one of the corners, A, B or C. In this case the line would pass through the point B ($x = 15$, $y = 45$) and the maximum profit would be $50 \times 15 + 15 \times 45 = 1{,}425$. In such problems, x, y, etc are called variables, while equations like $5x + y = 120$ are called constraints and the problem is to optimise a linear function like $P = 50x + 15y$.

Though this problem seems a trivial one, it has several important applications in problems that involve allocating time to production units in a factory, or warehousing of goods, or scheduling the transport of commodities. Economists have used programming methods for formulating simple models of economic activity. In fact, economists such as L. Kantorovich, Paul Samuelson and J. C Koopmans have been awarded the Nobel Prize for applications of programming to economics However, when the number of variables and number of constraint equations increase, the theoretical solution of looking at the extreme points becomes very laborious

We can most easily see how computations increase exponentially by considering another problem, in this class of problems, known as the travelling salesman problem. A salesman has to visit a number of places (say n) the distance between any two being known He has to choose a path which starts from his home town and returns to it after visiting each place, so that the total distance he travels is least In real life, a truck that is, say, delivering soft drinks to a number of retail outlets would have to solve a problem like this. One can ask a computer to look at each of the possible paths and add up the distances to see for which path the distance is minimum. There are (n-1) factorial possible paths and when n grows the problem grows faster than a^n, where a is an integer greater than or equal to one To give an example, for $n = 60$, $(n-1)$ factorial is such a large number that even if a computer were to do over a million computations a second, it would take it billions of centuries to do 59 factorial computations

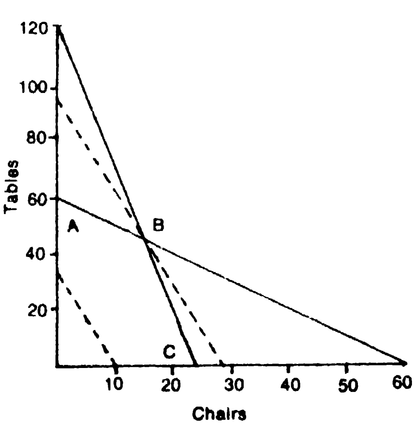


Fig.1 The solution of the problem by the simplex method

What is feasible for a computer to do, in a problem involving a large number of variables and constraints, is a computation that increases as a polynominal function of some input parameter, like either the number of variables or constraints in the problem. Thus for $n = 60$, if this power is, say, three, than 60^3 computations will have to be done. A computer doing a million computations a second will take only one-fifth of a second to do 60^3 computations.

Though in general the simplex method is exponentially growing, it can be applied successfully to many problems arising in practice because in these problems it requires only linearly growing steps. However, many problems reducible to the linear programming problems (and these include the above mentioned travelling salesman problem) could not be tackled in this way because in such cases the direct application of the simplex method to the corresponding linear programming problem requires exponential steps

Khachian's theoretical contribution lies in indicating an algorithm (a set of well-defined rules for the solution of the problem) for linear programming problems (which includes the travelling salesman problem) such that the number of computations increases polynomially, rather than exponentially, with the number of variables in some input parameter.

He proceeds by first observing that the problem of optimising a linear function subject to linear constraints can be reduced computationally to the problem of deciding when a system of linear inequalities is consistent In other words, to decide when a system of inequalities

$$\sum a_{ij} x_j \le b_i \text{ where } i = 1, \ldots, m,$$

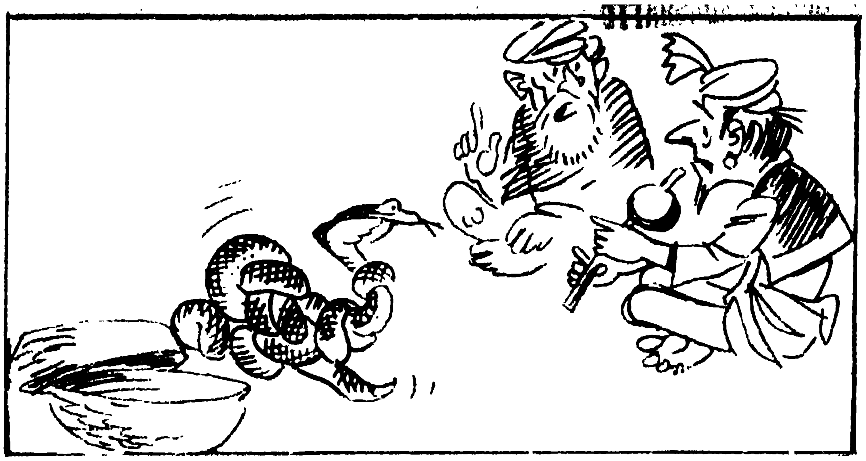
$$j = 1, \ldots, n, x_j \ge 0 \text{ and } a_{ij} \text{ and } b$$

are integers, has a solution. He then gives an inductive procedure to determine one such solution in $16n^4L$ steps, where L is a number depending on a_{ij}, b_i and n in an explicit way.

The procedure is quite tricky, involving construction of a nested sequence of $16n^4L$ ellipsoids in multidimensional space at the end of which one knows if the problem has a solution or not and at the same time can obtain one such solution if it exists. This does not mean that there exists a programme that can be put on the computer straightaway. However, a major step in this direction has been taken, and an algorithm that grows as a polynomial function has been shown to exist for a certain class of problems. It is only a matter of time and experience before a suitable computer programme is developed.

B. V. SINGBAL

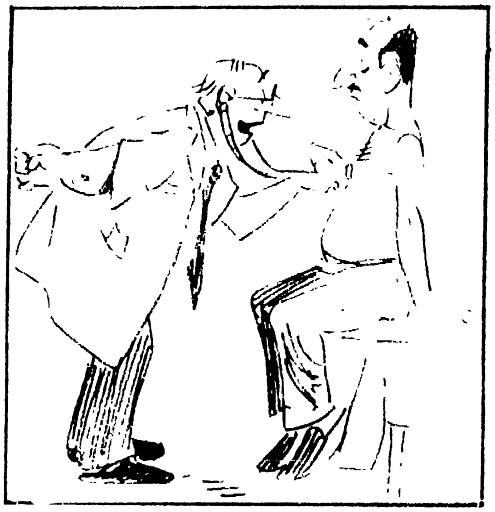
Dr. Singbal is with the Department of Mathematics, Tata Institute of Fundamental Research, Bombay.



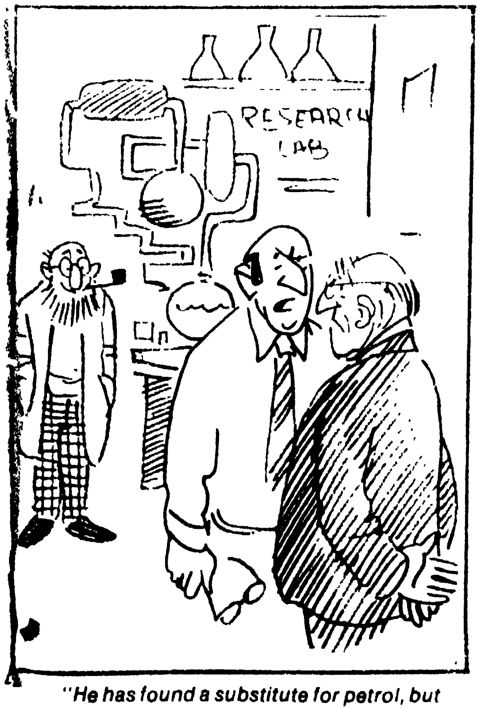
"I told you to stick to traditional tunes and not to try out rock music"

This World of Science!

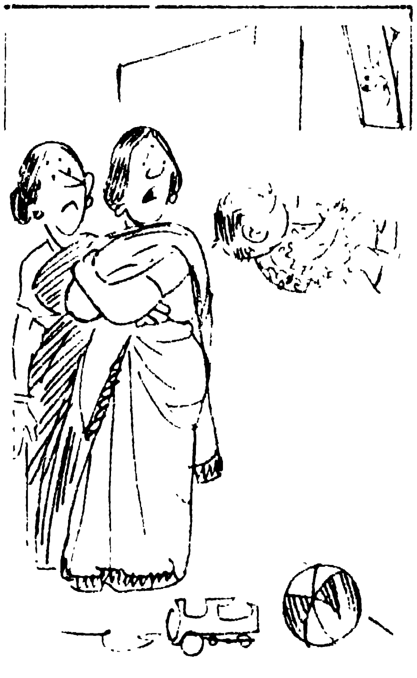
R.K. Laxman



"Yes, I'll be rather busy this year a seminar on cold in Manila, another one in Hawai on cough, yet another on headache in Rio"

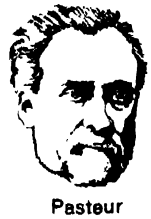


"He has found a substitute for petrol, but he won't reveal it unless he is paid the OPEC price per barrel."



"I want to show him to a psychiatrist. He is not at all like other kids of his age!"

In Lighter Moments
In Lighter Moments
In Lighter Moments

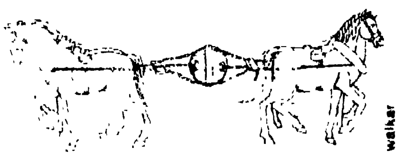


Pasteur

As with practically every discovery, Louis Pasteur's principle of immunisation was opposed even by well-meaning physicians. Once, while the Academy of Medicine was discussing this principle, tempers ran so high that Pasteur called one of his critics "stupid".

Thereupon, one Dr. Jules Guerin rushed at him to beat him. Some saner people intervened and the meeting was declared closed. However, Dr. Guerin could not take the abuse lying down; next day he challenged Pasteur to a duel. Unruffled, Pasteur reminded him: "Doctor, you know, my business is to heal, not to kill."

* * *



One need not be an existentialist metaphysician like Jean-Paul Sartre to prove the greatness and extraordinary power of "nothingness". It was on 8 May 1654, that the burgomaster of Magdeburg, Otto von Guericke demonstrated to a big gathering, including the German emperor and princes, that not even two teams of eight horses could pull apart two copper hemispheres joined together and from which the air had been evacuated. Thus was it proved that air is not nothing.

* * *

Heisenberg

When a physicist is faced with inconvenient facts that do not fit into any of the existing theories, he has to be bold enough to produce fresh hypotheses, even though they may appear far fetched.

It was such an explanatory hypothesis that Werner Heisenberg tried to advance in connection with the properties of elementary particles. Apropos of this, Neils Bohr commented: "This is undoubtedly a mad theory. The only thing is whether it is mad enough to be true."

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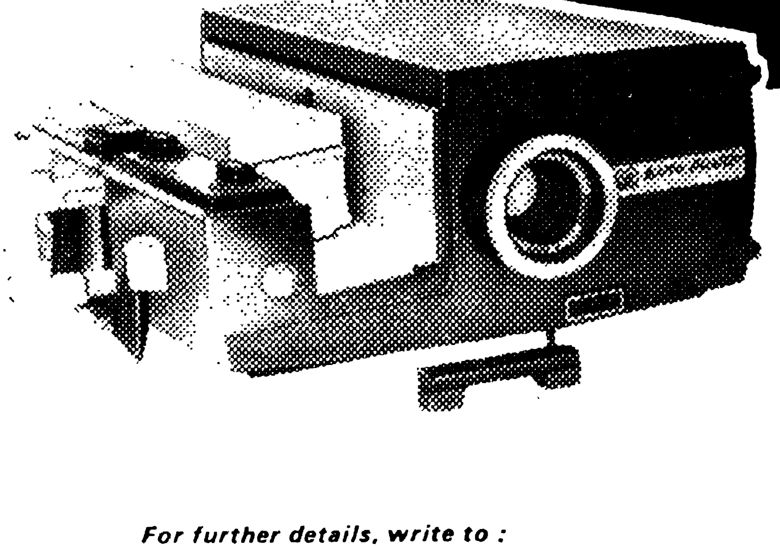

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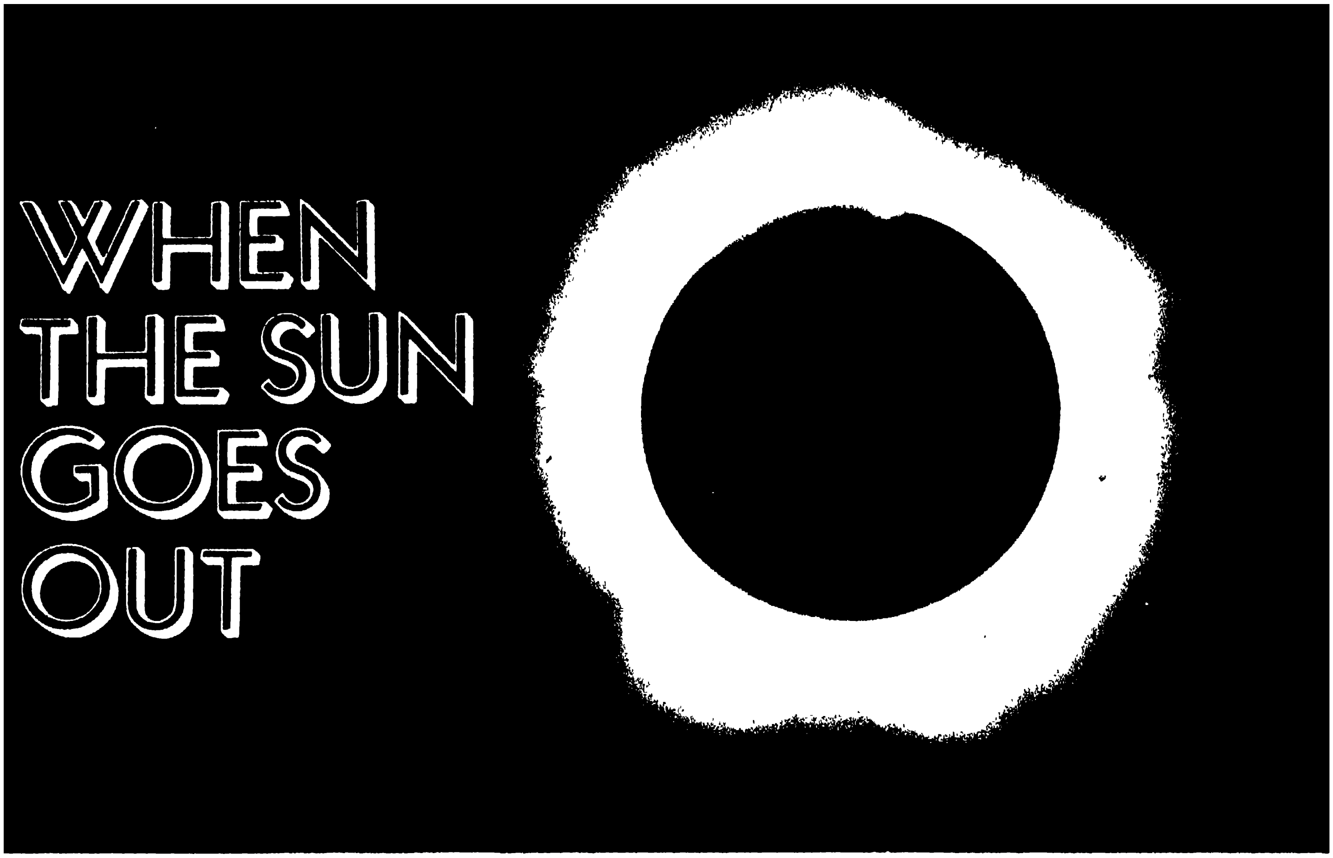
WHEN THE SUN GOES OUT



Above. Photo of the solar corona taken in Miahuatlan, Mexico, by the eclipse team of the Indian Institute of Astrophysics A 5 8-metre focal length camera was used Below Diagram of shadow bands Reproduced from *The story of eclipses* by G F Chambers published in 1902

M.K.V. Bappu

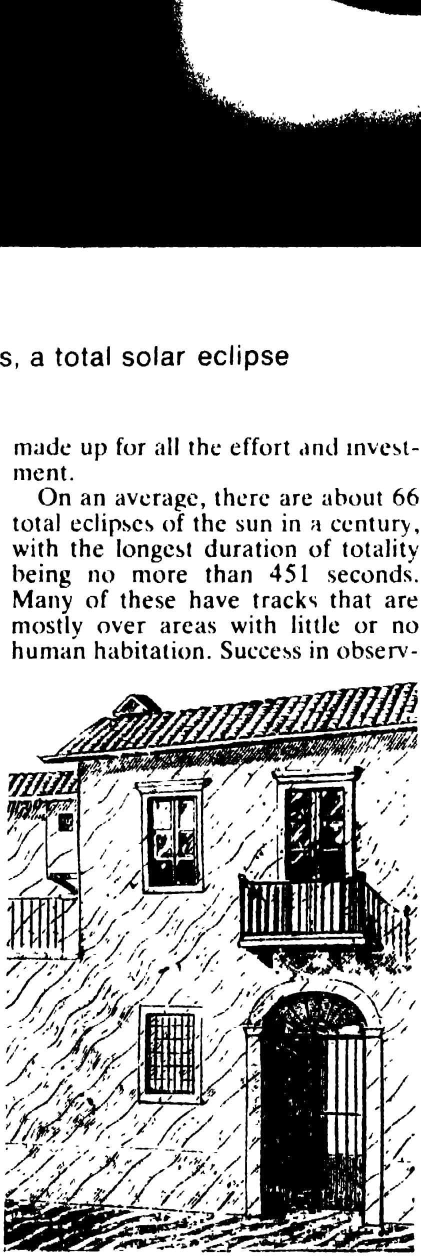
One of nature's grandest displays, a total solar eclipse can be inspiring, even awesome

THERE WAS an air of hushed expectancy in our camp as I saw the moon's shadow approach from the distant hills in the west. In a few seconds the last traces of the sun's brilliant disc would be covered by the moon bringing into view the ruddy chromosphere and pearly white corona.

My first task was to announce this instant. Viewing the disappearance of the bright solar disk through a monocular with a transmission grating ahead of it, the bright lines of the chromosphere flashed into view replacing the dark absorption lines of the normally visible solar photosphere. For the next 203 seconds, my team-mate and I were to carry out a programme of photographing the coronal form and its spectrum. We had travelled nearly 20,000 km to the village of Miahuatlan in Mexico, carrying along four tonnes of equipment, to observe this total solar eclipse of 7 March, 1970.

The few preceding weeks had made heavy demands on our reserves of energy and resourcefulness. But in those few seconds of totality, when a cloudless sky revealed the glorious spectacle of the corona, making our programme a success, we more than made up for all the effort and investment.

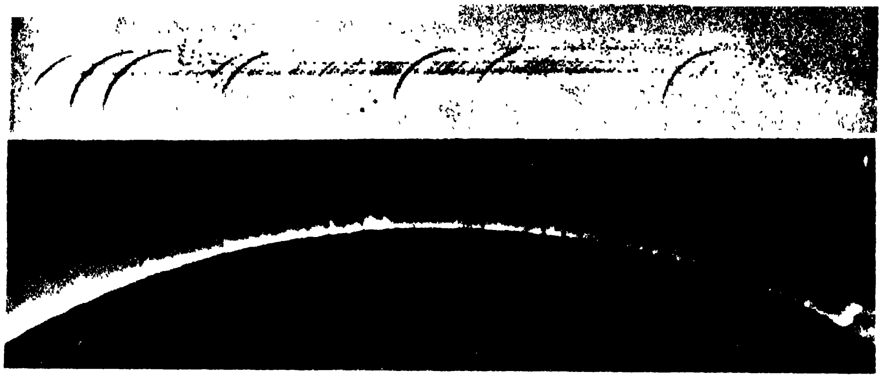
On an average, there are about 66 total eclipses of the sun in a century, with the longest duration of totality being no more than 451 seconds. Many of these have tracks that are mostly over areas with little or no human habitation. Success in observing the remaining few depends heavily on the weather; the best plans of many expeditions in the past have been foiled by a stray cloud that happened to cover up the sun during the critical duration of totality. On the other hand, there are rare instances of extreme good luck, as the one I had at Maine, USA, on 20 July 1963, when a gap in the thick clouds, just when and where it was needed, enabled us witness the spectacle. Eclipse lore has much more to tell on the near escapes and disappointments that previous observers have experienced in this regard.



Why then do solar physicists attempt to make such eclipse observations when they are so fraught with uncertainty? The answer lies in the fact that total solar eclipses have hitherto been the only occasions when studies of the sun's chromosphere and corona could be made in great detail. With the bright light of the visible disc completely cut off, we can examine the characteristics of the faint distended outer atmosphere of the sun.

The physical processes at work in these regions are of great interest,

not only from the standpoint of the origin of excitation and extent of the solar atmosphere, but also for providing information on the radiative flux responsible for the formation of the earth's ionosphere as well as the charged matter that makes up the solar wind. Much of the basis of our understanding of these regions of the solar atmosphere has been the information collected during eclipses that would span a total observing time of just a quarter hour in almost a century


Top Flash spectrum of the chromosphere at second contact during the January 1898 eclipse at Jeur, Maharashtra Above Chromosphere photographed in white light. The small jet-like features are the spicules At the far right is a small prominence (Lick Observatory Expedition, Jeur)

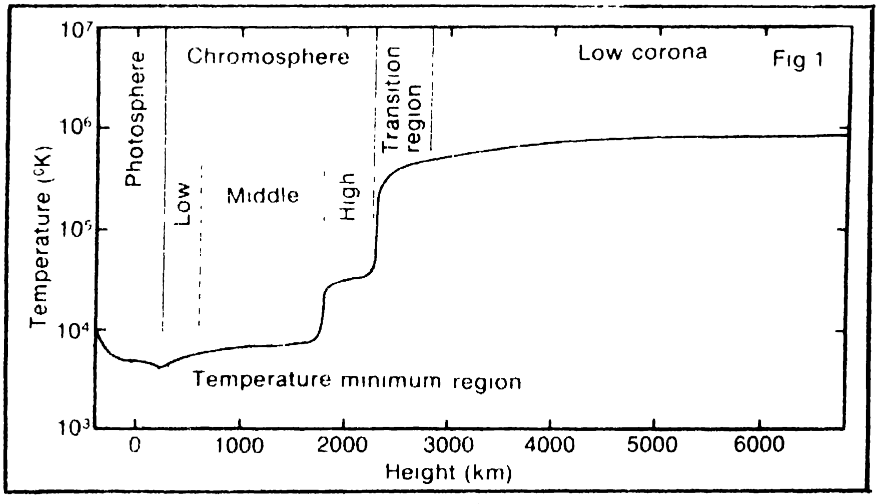
As I write this, numerous teams in different countries are busy preparing to observe such an event in India on 16 February 1980. This is the first occasion during the twentieth century when a total eclipse track will cross the Indian peninsula. Three eclipses during the last century, as observed from India, have already helped lay some of the foundations of solar physics.

The most important, historically, was the one of 18 August, 1868, which the British and French teams, together with the Madras Observatory team, studied. All teams used spectrometers and established that the prominences were gaseous in nature as inferred from the emission lines of hydrogen. The prominence spectrum also displayed a bright yellow line more refrangible than the well known D lines of sodium. This observation in India was the first ever made of helium. Recognised as a new element in the solar spectrum, it was 27 years later that Ramsay isolated it from the mineral cleveite

The next eclipse in India was on 12 December 1871 with the track of totality passing through Ooty and Pudukotah, in Tamil Nadu. This eclipse is memorable for the French astrophysicist Janssen's discovery of the Fraunhofer corona by the observation of weak and shallow Fraunhofer lines, especially those of sodium; Janssen also saw weak hydrogen emission in the corona.

The eclipse of 22 January 1898, the path of which cut across the country from Ratnagiri through Rewa, had observing teams all along the path of totality. Evershed obtained ultraviolet spectra of the chromosphere and prominences, and found continuous emission shortward of the Balmer limit, a feature which is most usefully exploited in present day studies for the determination of electron temperature and density.

The recurrence of a similar event 82 years later in the same region of the world quite naturally evokes considerable interest. The shadow will enter the west coast of India at Ankola and leave at Puri on the east coast. The shadow cone will first touch the earth's surface in the mid-Atlantic and after sweeping over the continent of Africa, the southern part of India, Bangla Desh and Burma, will leave the earth at a location in southern China. The maximum duration of totality will be 252 seconds near the east African coast. In India, totality will be of the order of 170 seconds on the west coast and 136 seconds at Puri. The altitude of the sun above the horizon will be 39° and 24° at the two respective places. February, with its clear skies, is one of the best months for astronomical observation in India. Here is then an occasion of the greatest interest not only to both professional and amateur astronomers, but also to anybody who appreciates beauty in nature.

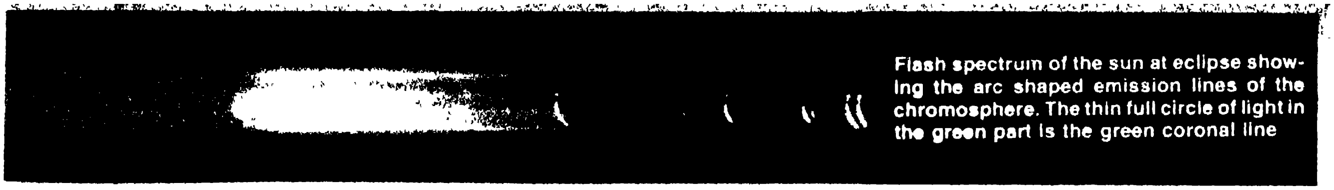


The mean temperature variation with height in the chromosphere and corona

The red annulus seen just adjacent to the bright vanishing disk of the eclipsed sun is termed the chromosphere. The emission line spectrum of this layer, which in some places can be as high as 3,000 km, constitutes the flash spectrum discovered in 1870 by Young of Princeton The spectrum of the chromosphere is best observed at a total eclipse, although Pogson of the Madras Observatory had demonstrated in 1872 that it could be viewed even during an annular eclipse. The eclipse is necessary to block out the normally intense photospheric radiation. Otherwise, the scattered light will reduce the chromospheric lines to near invisibility. A coronagraph, which is a telescope that produces artificial eclipses of the sun, can be used to some advantage to study the higher regions of the chromosphere. But for quantitative researches involving photometric studies of continua, emission line intensities and spectral line profiles, which are essential for an understanding of the chromosphere, a total solar eclipse is best.

The chromospheric spectrum consists primarily of emission lines of the excited atoms as well as those from which one or more electrons have been stripped. A continuum is present, the characteristics of which depend on wavelength as well as height in the chromosphere. Farther outward from the limb, as one leaves the chromosphere and examines the coronal spectrum, we see a weak emission spectrum of a few lines superposed over a continuous spectrum. These coronal emission lines are forbidden lines of highly ionised atoms; the brightest line in the green region of the spectrum, first seen in 1869 by Harkness, was identified only

SCIENCE TODAY FEBRUARY 1980



Flash spectrum of the sun at eclipse showing the arc shaped emission lines of the chromosphere. The thin full circle of light in the green part is the green coronal line

in 1942 as being due to the iron atom stripped of 13 of its electrons.

We, therefore, conclude that the solar atmosphere, instead of becoming cooler with increasing distance from the limb, actually experiences a sharp increase in temperature; from a temperature minimum of 4,300° K tentatively located at a height of 200 km beyond the limb, the value increases to 6,000°K in the low chromosphere, 20,000°K in the upper chromosphere at heights of 2,000 km, and a very sharp increase into the million degree domain in the corona thereafter. A temperature profile of these outer layers of the solar atmosphere can be seen in Fig.1 with the transition to coronal temperatures confined to a few hundred kilometers.

These phenomena indicate the strong contribution of non-radiative energy sources that are responsible not only for the abnormal excitation, but also for the density gradients indicative of distension. Direct evidence for such forces comes from a scrutiny of the upper chromosphere boundary either during eclipse or otherwise, when one sees numerous jet-like features of short duration known as spicules. These jets penetrate the chromosphere-corona transition boundary and exist in the low coronal regions. Many of them go up to heights of 10,000 km or more with velocities of the order of 20 km per second and lifetimes of five to ten minutes. They are associated with the boundaries of the large-scale convective network where vertical magnetic fields tend to be concentrated. Their temperatures are near 15,000°K. Further study can improve these values.

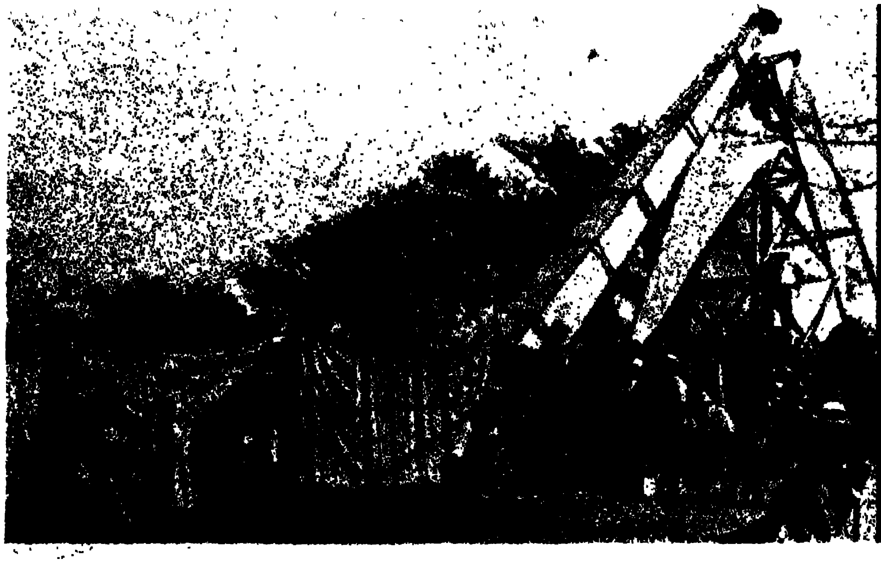
Sky and Telescope

Above the 26 February 1979 total solar eclipse This one-second exposure at f/4 on Kodachrome 25 film was made about 30 seconds after totality began.

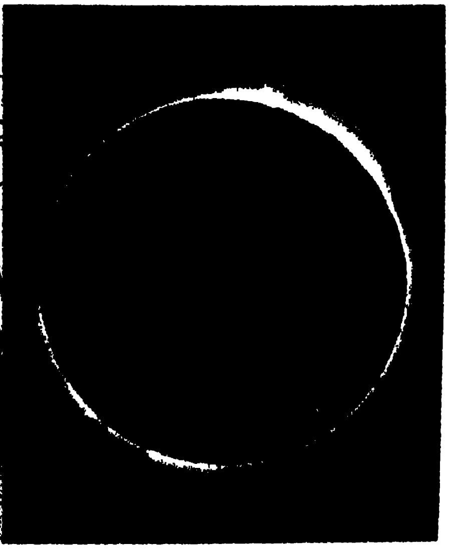
A schematic diagram of the solar chromosphere can be seen in Fig.2. A complex situation prevails in terms of energy balance. Spicules occupy about one per cent of the solar surface at any time and the energy flux averaged over the sun is comparable to the energy needs for heating the chromosphere and corona. In addition we have the role of magnetic fields that contribute to both energy balance and structural detail. Energy losses in the corona are principally by inward thermal conduction through the transition region as well as by radiation. The loss by means of the solar wind (a continuous outflow of particles from the sun) is less by a large factor. In the chromosphere, the losses are mostly by radiation. Three sources of dominant radiation loss in the chromosphere are the Lyman-alpha in the upper chromosphere; the line emission of singly ionised and neutral elements in the middle chromosphere; and the continuum radiation in the form of emission by negative hydrogen ions in the low chromosphere.

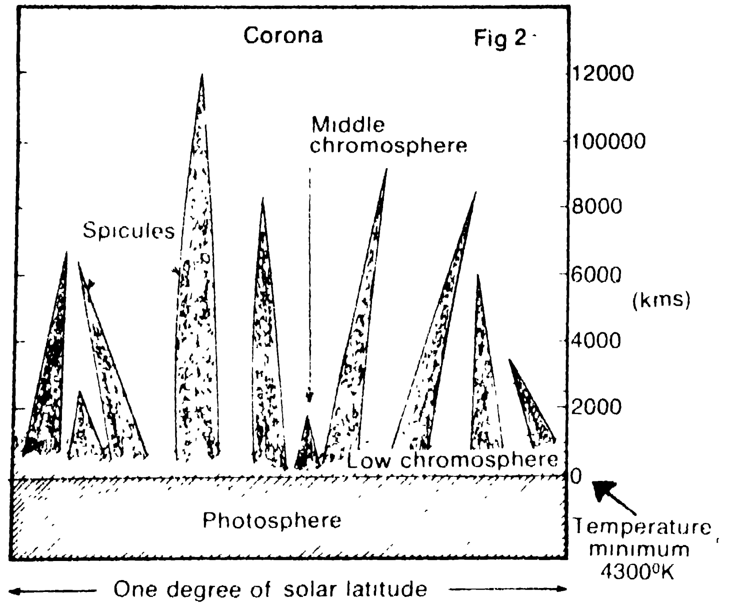
Eclipses have been the primary source of data for studying the sun's corona. The development of the coronagraph has greatly aided such

The eclipse of 22 January 1898 at Jeur in Maharashtra Photo shows the Lick observatory's eclipse team with their coronal camera The camera was not guided, it had to be pointed ahead of time to the position where the sun and moon would seem to meet

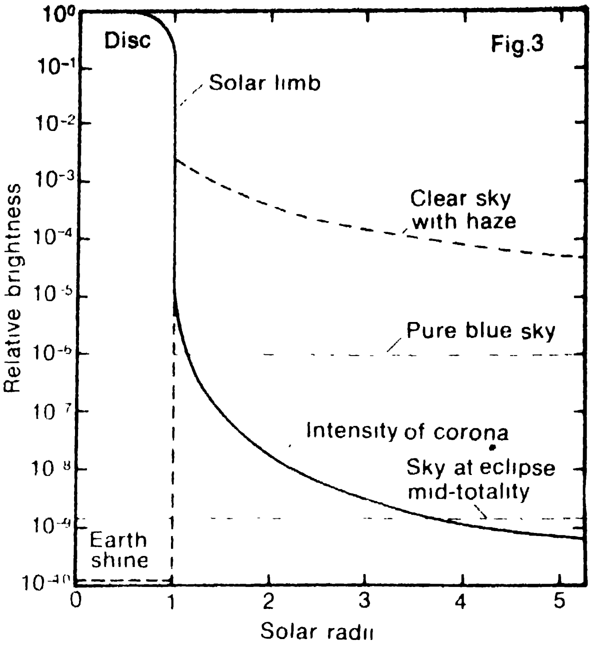


The chromosphere can be seen only for a few seconds just as the last bit of the sun is being covered by the moon





Schematic diagram of the chromospheric features Note spicule heights and the relative heights of low and middle chromosphere



Coronal intensities and sky brightness values

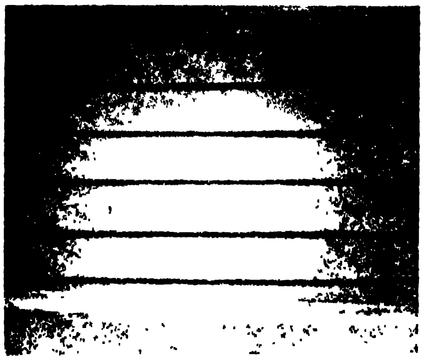
study with regard to time variant aspects of coronal forms and emission line intensities. In recent years space observations in the XUV have transformed this feature considerably by making it possible to study the corona over the disk. A dramatic new era of observation thus ushered in enables us to discuss x-ray emission over active regions, the presence of coronal holes, and association of these features with limb phenomena seen at eclipses or with the aid of coronagraphs. In combination with high resolution radio astronomical techniques, we have powerful new possibilities of studying coronal physics. In this repertoire, ground-based eclipse observation still forms a valuable means to study the coronal form, its spectrum and structural inhomogeneities.

The relative brightnesses of the solar disc, solar corona and sky brightness can be seen in Fig.3. The corona near the limb can be examined with a spectroscope attached to a coronagraph in a "pure blue sky", the kind one can have occasionally at mountain locations, higher than 2,500 metres. On rare occasions when the sky brightness near the limb is as low as 10^{-5} or less of the value on the disc, as it can be at altitudes of 3,000 metres or greater, coronal structures can be photographed by an instrumental combination of narrow band filter and coronagraph. On the other hand, when the moon blocks out the photospheric light, the sky brightness near the limb at mid-totality falls to such low levels that coronal intensities, a billionth in brightness of the solar disc, can be photographed out to almost four solar radii. It's no wonder why so many individuals with the instinct for adventure have faced numerous odds and have travelled far to capitalise on these few moments of totality. Janssen's effort of escaping with his equipment, in a balloon from a besieged Paris, to observe the 22 December 1870 eclipse has almost the dramatic aspects of an Alexander Dumas tale.

There are many interesting happenings to observe during the few moments around totality. First, a minute before totality, the shadow of the moon sweeps by the observer at 800 m/sec, and the shadow bands appear. The bands can be photographed on an extended white surface (a few linen sheets spread on the ground or on a white wall). These shadows arise because of scintillation effects on the bright bead-like points on the vanishing or reappearing crescent of the sun. Many plants that close up before sunset do so as totality approaches, and open up again for the day as normal brightness is restored. The eclipse evokes a similar response in the animal kingdom. Pigeons go to roost, owls and bats come out of hiding, and cocks may crow. Only the ants seem unperturbed by the event.

This month's total eclipse will provide a fine opportunity for the study of spicule spectra, and profiles of both absorption and emission lines from near the temperature minimum to the upper chromosphere. Freedom from photospheric scattered light will make observations of high spectral and good spatial resolutions a distinct possibility. A slit-spectroscopic rapid scan of the chromospheric layers, determination of the scale height of the atmosphere by the use of limb-darkening effects, and white light photography of sun's limb on the slit are other possibilities of leading to new knowledge. The eclipse will also undoubtedly be used to clarify many points regarding coronal rotation, spatial variation of coronal temperatures and the subtle excitation differences associated with coronal form. And today's sophisticated instrumentation is expected to make many of the endeavours a success.

Photograph of the shadow bands, see the periphery of white area



Prof Bappu, 52, Director of the Indian Institute of Astrophysics, Bangalore, since 1960, is well known for his 'Wilson-Bappu effect' that is extensively used for the determination of stellar distances. He is the first Indian to be elected President of the International Astronomical Union for the term 1979-82. A member of several other international scientific bodies, Prof. Bappu was the recepient of the Shanti Swarup Bhatnagar Prize in 1970.

Eclipses in mythology

ECLIPSES have, through the ages, inspired myths simply because its awesome rarity has excited human imagination.

The Egyptian cult of Ra, the sun god, is possibly the most ancient. He set out as Khepri, the giant scarab, on his immutably regulated journey across the heavens in a golden barque attended to by his minions Ra had to be on guard all the while against the wily attacks of the great serpent Apep, who symbolised evil. Apep occasionally succeeded in swallowing the golden barque, but would be immediately vanquished by Ra's defenders and made to flee

The classical Chinese text *Chou-king* claims the honour of the earliest recording of eclipses --the lunar eclipse of 1136 BC and a solar eclipse in either 2136 BC or 2128 BC Since a monstrous dragon was believed to devour the heavenly bodies, royal astronomers were ordained to supervise the placatory rites of shooting arrows and beating drums. One ancient solar eclipse is memorable for the dire fate of two astronomers who were too drunk to perform their duties.

> *Here lie the bodies of Ho and Hi*
> *Whose fate though sad was risible,*
> *Being hanged because they could not spy*
> *The eclipse which was invisible*

wrote a clever rhymster of the time

In Japanese lore *Kojki* and *Nihon Shoki* too an eclipse is interpreted as a struggle between the gods of Yamato and Izumo provinces. Like in some Slavic myths, the sun is a goddess called Amaterasu, also a high priestess who wove clothing for the gods. She was from Yamato and an ancestor of the imperial family Susanoo, her brother, represented Uzume, the rival province One day, while Amaterasu was weaving in a sacred place, Susanoo threw down a dead piebald horse through a hole in the roof The terrified goddess hid in a rocky cave of heaven, closing the entrance with a boulder. The world was plunged into darkness for abetting the wicked gods. How a myriad of good gods planned to release Amaterasu is another story.

Most of the American Indians and also the Incas of Peru were followers of a powerful sun cult. Calling him Inti, the Incas visualised him in human form with a face formed by a golden disc emanating rays. Solar eclipses were portents of Inti's terrible anger requiring propitiatory human sacrifice.

The negroes of Zambezi have a charming story attributing jealously to the pale moon who stole the fiery feathers of the sun while he was looking at the other side of the earth. The angry sun splashed the moon with mud which stuck on eternally. An avenging moon waits to catch the sun off guard and once in about ten years returns the compliment of a mud splash! The sun then exhibits large spots and cannot shine for some hours, causing gloom among men and animals who love his light

Hindu eclipse lore is an offshoot of the classic churning of the primordial ocean by gods and demons for obtaining ambrosia, the food which conferred everlasting youth and beauty The gods were drinking it in tumultuous excitement after Vishnu wrested the ambrosia from the demons. Rahu, a demon, assumed godly form and tasted ambrosia. The sun and the moon spotted him and alerted Vishnu who beheaded him with a sling of his powerful discus. Rahu's huge torso fell on the earth splitting its surface and the mountainous head rose in the sky forming the ascending node Thus began the deadly wrath of Rahu who periodically swallows the heavenly bodies Popular lore has made Rahu and Ketu (the severed trunk) into serpents, the archetypal embodiments of evil.

Historical eclipses

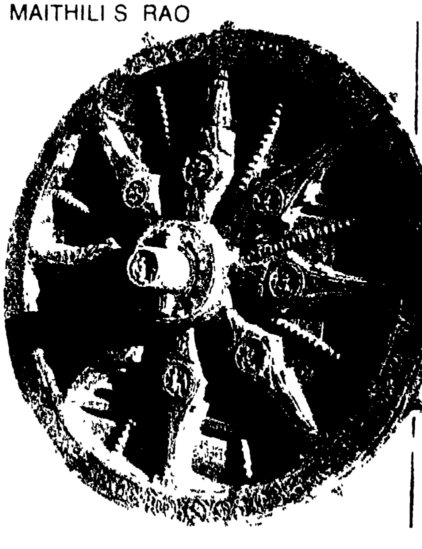
The Greek astronomers shunned myths, concentrated on recording the dates and observed the phenomena. For example, Thucydides pinpoints a solar eclipse (at mid-day at the beginning of a new lunar month) as the first year of the Peloponnesian war. Verification by astronomers fixes the date as 3 August 431 BC Homer was not as accurate as the historians. In the Odyssey he says

> *And the sun was utterly*
> *perished from heaven*
> *And an evil gloom is overspread*

but at that time, the festival of the new moon was being celebrated It was indulgence in poetic hyperbole

Presuming for argument that the story of the Mahabharata war is true, can it be dated with some precision following the clue of an eclipse? Abhimanyu, the beloved son of Arjuna, was killed by Jayadratha on the thirteenth day of the war. Arjuna vowed to kill him by sunset the next day Javadratha was massively guarded for some 12 miles behind the battle-lines, but Arjuna reached the entrenched position by late afternoon As the battle raged furiously, the sun neared the crimson horizon and suddenly, it was dark Jayadratha came out assuming that the sun had set and was killed Was the darkness at Kuruksehtra a magical intervention of Krishna or merely a solar eclipse?

MAITHILI S RAO

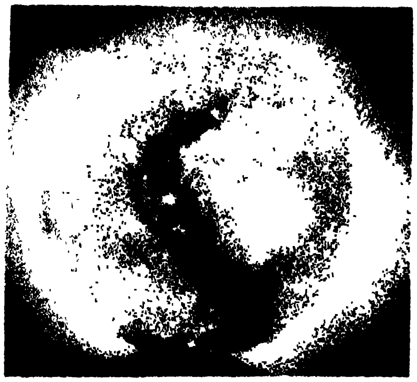


The sun wheel (Konarak temple, Orissa)

How well do we know our sun?

S. M. Chitre

Is our middle-aged sun not at its best these days?



The sun with X-ray eyes A skylab picture displays the corona at temperatures of about two million° K

WITH THOUSANDS of millions of stars in our galaxy, some of them known to be particularly exotic and interesting, why do astronomers devote so much effort studying the sun?

The sun is not just another star. Its proximity enables us to study its surface features in some detail. Its space environment can be closely probed and its light minutely analysed to reveal the presence of a host of surface elements. Other stars, being much farther away, are too faint to be studied with present-day instruments to a degree that is possible for the sun. There is the hope that the study of the sun will be a step towards better understanding of stellar structure, since phenomena that occur on our sun are expected to work for other stars as well. More important, it is desirable to understand the processes that sustain the brightness of the sun. Because, hopefully, some day we will be able to reproduce these conditions in fusion reactors or improve the existing methods to tap the virtually inexhaustible supply of solar energy. There is also the need to study the sun for a better understanding of the weather and climate.

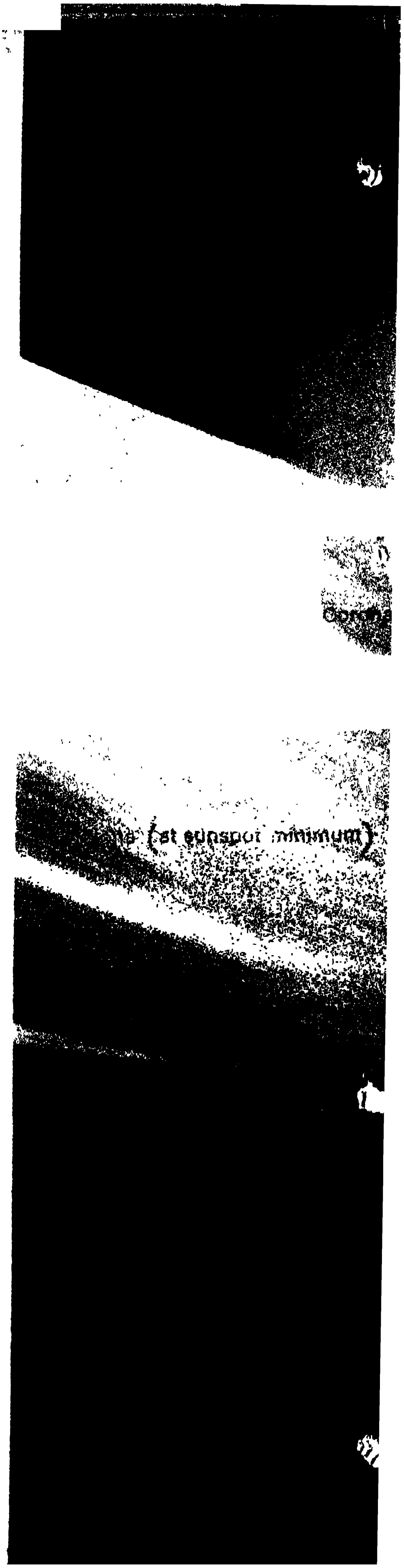
The solar interior

Although the internal regions of the sun are hidden from direct observation, it is nevertheless possible to construct a reasonable picture of its interior. The physical assumptions ll us that the temperature in the central regions, where the thermonuclear reactions take place, is around 15 million degrees Kelvin. The density there is a hundred times that of water.

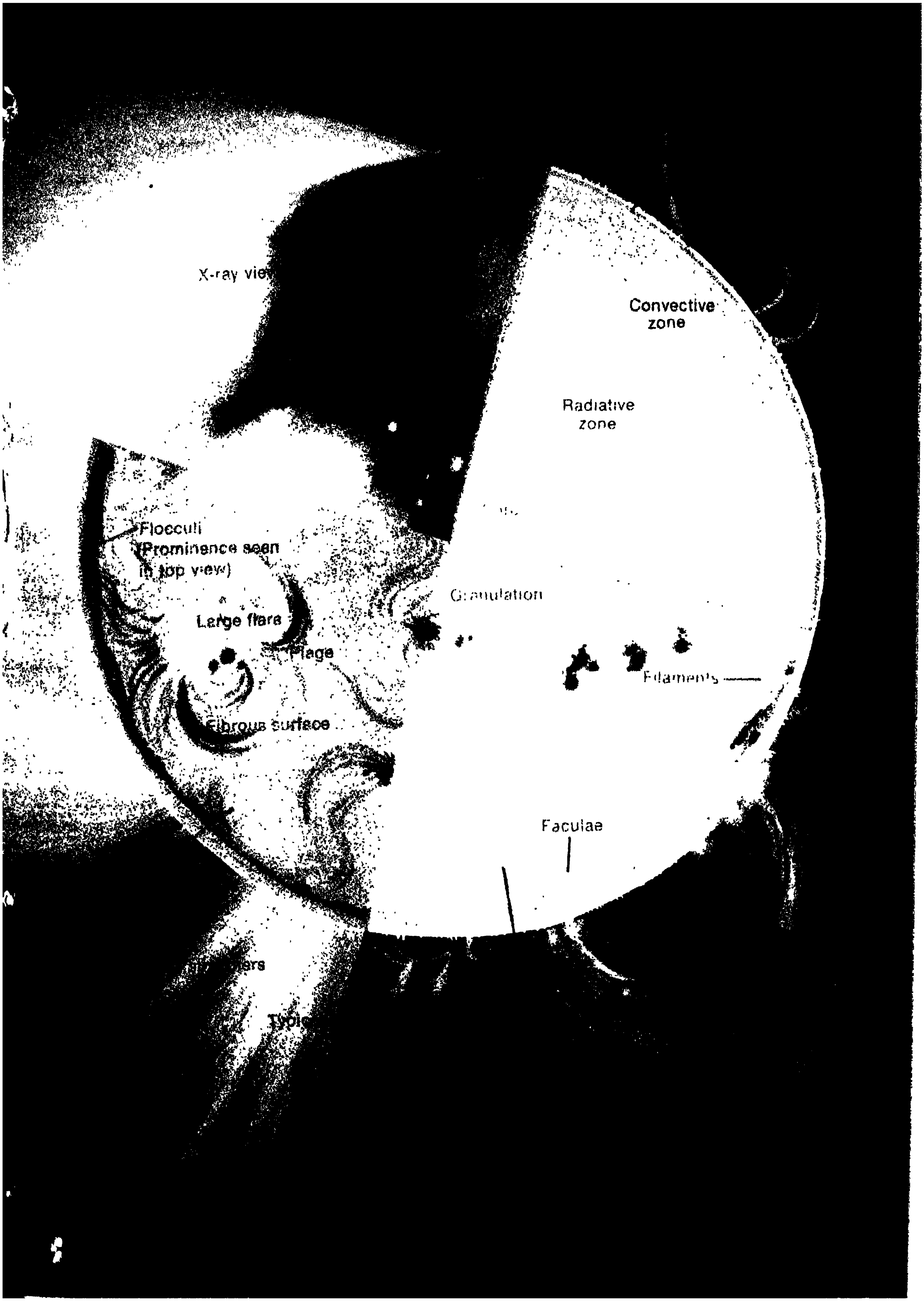
The basic nuclear energy generating source is the fusion of four protons to form a helium nucleus having a mass that is less than the original four protons by a mere 0.8 per cent. But what does that missing mass getting converted to energy for a star like the sun mean? Very much—hydrogen fuel is to last about ten billion years. Our middle-aged sun has another five billion years to go.

Outside the core is the convection zone. Here, like the boiling of water in a kettle, turbulent motions of gases transport the energy that is generated in the core towards the photosphere, the layer visible to us. But it is hopeless trying to see the photons emerging from the deep interior; only the light emitted by the outermost layers is available to us for inspection. However, there is one particle, the neutrino, which is formed as a by-product in the thermonuclear reactions. Neutrinos can stream out unimpeded to the surface and escape into the surrounding space. So, if we can capture these neutrinos they would offer us the opportunity to understand better the sun's energy generation process. The count of neutrinos captured should provide a handle to determine the central temperature and density of the sun.

Other possible clues about the interior are provided by the variety of mass motions observed at the solar surface. These can be ordered in a set of well-defined classes: small-scale circulation patterns (granulation), with average sizes of 1,000 km and a characteristic life-time of 10 minutes; moderate-scale circulation patterns (super-granulation) with approximate sizes of 30,000 km lasting for about 20 hours; very large-scale motions which occupy a substantial portion of the entire solar body like giant cells. Besides these there are the short-period oscillatory motions having periods predominantly centred around 5 minutes with associated cell-sizes of 5,000 to 10,000 km, and the global oscillations with long periods ranging from 15 minutes to an hour.



Anatomy of the sun


X-ray view
Convective zone
Radiative zone
Flocculi (Prominence seen in top view)
Large flare
Granulation
Plage
Filaments
Fibrous surface
Faculae
ers
Typic

Even though the existence of velocity fields on the solar surface has been known for quite some time, their role as diagnostic tools to probe the structure of the sun has received attention only in recent years. Analogous to the seismic waves generated by earthquakes which have helped in telling us about the earth's interior, the oscillations of the sun can reveal considerable information about its internal layers.

The solar environment

The sun's environment cannot normally be seen from earth except when a total eclipse blocks light from the photosphere or when special instruments designed to cut out the light are used. Immediately before and after totality, during an eclipse, there appears a bright pinkish glow at the solar limb. This reveals the sun's chromosphere which extends some 2,500 km above the photosphere with its temperature approaching several tens of thousand degrees. Above the chromosphere is the corona, appearing as a faint halo. The corona extends a million kilometers into space and has a temperature upward of a million degrees. The magnificent view that the corona presents during a total solar eclipse has fascinated man for ages. A Babylonian account of 1062 BC says, " the day was turned into night and there was fire in the midst of heaven."

It is generally believed that the chromosphere is being heated up by sound waves produced in the convection zone below the photosphere, which travel outwards depositing their energy in the overlying layers. However, its detailed mechanism is still not adequately understood.

A spectroscopic study of the chromosphere reveals a large network pattern which is the location from which brilliant jets of gas (spicules) leap, like flames from a forest fire, to heights of several thousand kilometers and then fade in a matter of 5 to 10 minutes. The corona also shows many structures that include streamers extending radially outwards, loops closer to the chromosphere and plumes above the poles. These point to the existence of a magnetic field which appears to control movement of the coronal gas. In 1908, G. E. Hale found that when the slit of his spectrograph was focussed on a sunspot, there was a magnetic field a thousand times stronger than the field in the undisturbed neighbouring regions.

Huge eruptive prominence observed on 9 April, 1979 from Vedhshala, Udaipur Solar Observatory The solar material was thrown out to over 100,000 km with the speed of 200 km per second

The puzzle of the high temperature in the corona is believed to be connected with the disturbances in the magnetic field generated by motions at the surface. Because of the rapid decrease in density outwards, the sound waves generated in the turbulent convection zone are accelerated to shocks. Also, the decrease in density leads to an increased capability of the magnetic fields to carry the energy flux. These two effects combine resulting in the propagating waves which are supposed to deposit their energy at the base of the corona. It is possible that the wave propagation and energy deposition play relatively minor roles in heating the corona. An alternative mechanism relies on the magnetic field and the ohmic dissipation of electric currents arising from the field variations as a plausible energy source. In any case, the question, "what is the energy source for the chromosphere and corona" still awaits an answer.

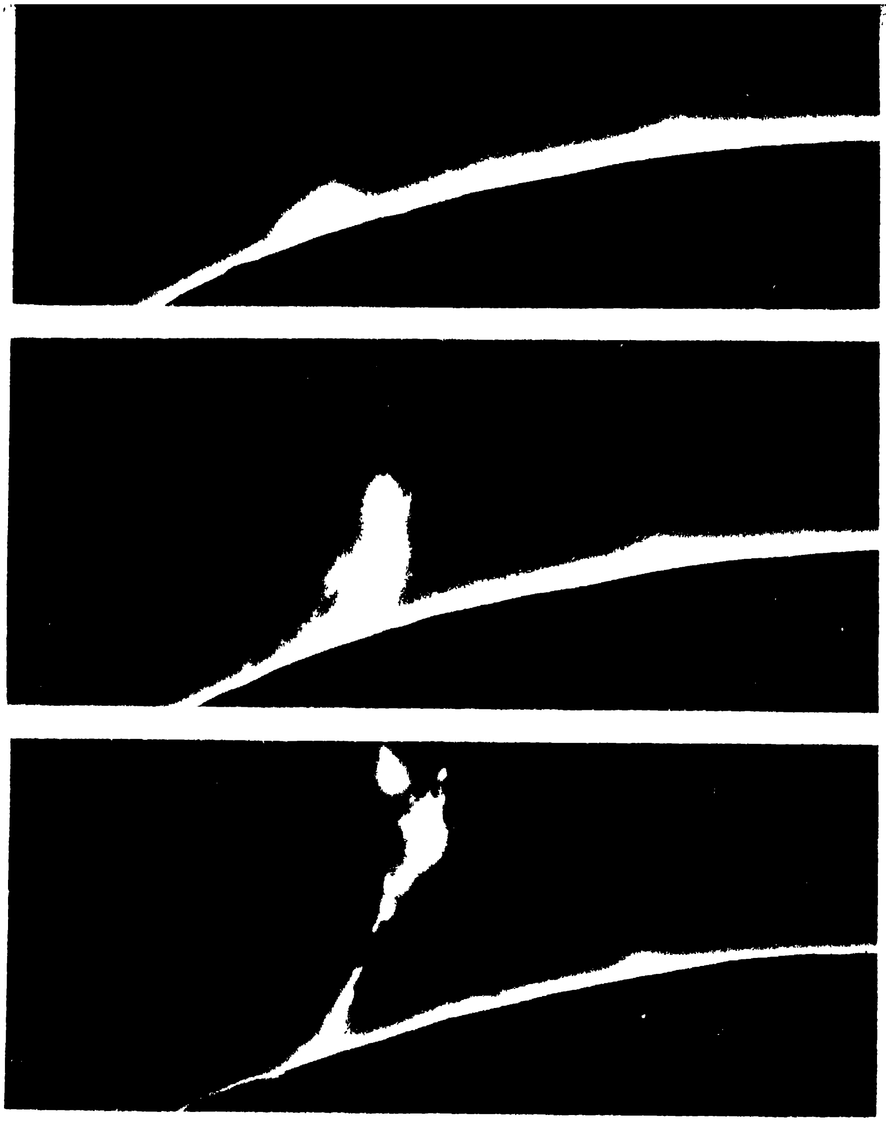
Large solar flare of 3 April 1979 observed from Vedhshala Udaipur Solar Observatory A solar flare B filament and C sunspot

Most of the observations of the corona have been made during eclipses, but in the last few years, solar astronomers have examined the coronal structure extensively from space platforms like the Orbiting Solar Observatory and the Skylab. x-ray pictures by the Skylab reveal structures in the corona ranging from relatively bright points, typically as large as the earth and distributed uniformly over the solar disc, to extensive features occupying as much as a quarter of the solar surface. These generally resemble closed arches or loops indicating that magnetic control of the coronal gas forces it to move along the lines of force. Radiation received by radio telescopes is another indication of the million degree temperature in the corona.

Astronomers have been aware since the early 1960s that the corona is in the process of continuous expansion—an outflow in the form of a solar wind of charged particles streaming in space well beyond the orbit of earth. The effect of the solar wind can be seen from the cometary tails which are blown away from the sun, and also from the sweeping up of the solar magnetic field into space.

Skylab observations revealed the presence of some regions in the corona with relatively lower-than-normal density and temperature. Here the magnetic field lines are predominantly divergent, extending radially outward. As a result of the open magnetic field lines, the coronal plasma is not trapped in the regions of the holes. The high-speed solar winds streaming into space impinge on the earth's magnetic field to produce recurrent geomagnetic storms. There is as yet no satisfactory mechanism proposed to explain the high-velocity wind streams from the coronal holes.

The conditions of low density and temperature prevailing at these sites may indicate that a large part of the energy supplied to the corona does not contribute to its heating, but rather to accelerating the solar wind



Eruptive solar prominence observed on 20 December 1978 at 1215 hrs IST from Vedhshala, Udaipur Solar Observatory. Solar material was ejected to over 80,000 km from the sun's surface with a speed of about 400 km per second

The disturbed sun

The changing appearance and disappearance of the sunspots (see box) are the most evident signs of disturbances on the sun. Hale discovered that the spot regions have very strong magnetic fields, as high as 3,000 gauss. Sunspots look dark because they are cooler by about 1,500° compared to the normal photosphere.

Sunspots are but one aspect of the activity taking place on the sun. The levels above the photosphere also show disturbances—called plages or faculae—when viewed with special filters in hydrogen and calcium light. The active regions around the sunspots erupt in huge bomb-like explosions, called flares, which release an enormous amount of energy in a matter of seconds. The temperature in the flare region can reach up to several million degrees Kelvin resulting in the production of x-rays which have been observed by instruments on the spacecrafts. The hot gases and radiation ejected by a powerful flare travel out, and when these disturbances hit the earth's magnetic field and the atmosphere they produce a number of effects like lights visible in the high latitudes (auroras), breakdown of radio communication or power transmission and so on.

The magnetic fields are supposed to play an important role in the production of prominences, large arch-like structures, and in guiding the solar material along them. Sunspots, flares and prominences are all phenomena directly linked with the activity gen-

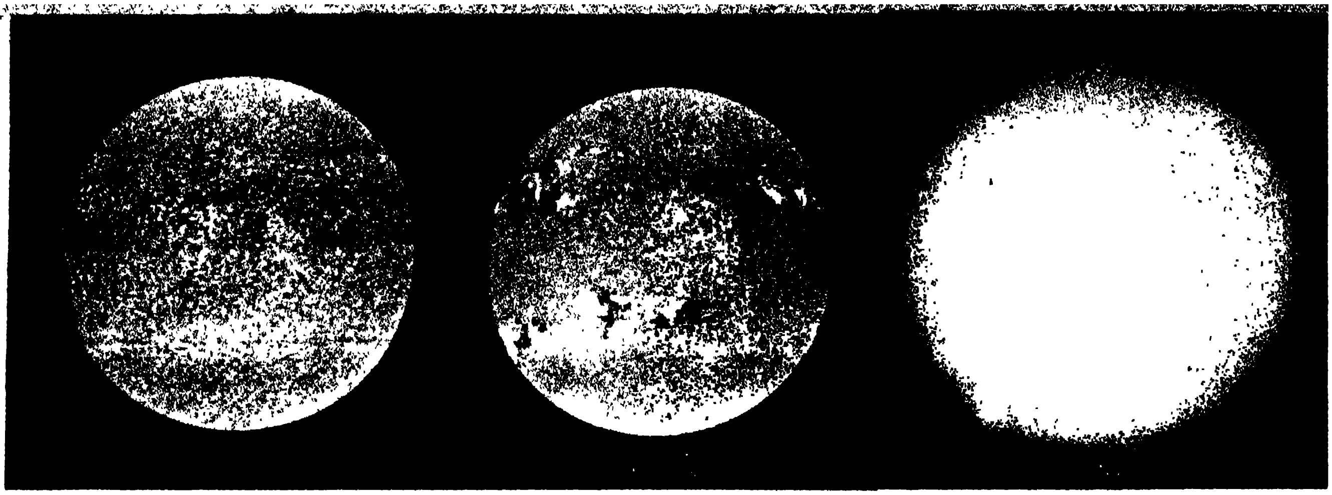
Sunspots can be confusing!

ALTHOUGH sunspots have been studied for centuries, it was only during the middle of the 19th century that astronomers noticed that the number of sunspots and other active phenomena varied with time in a cyclic fashion. While at times there are hardly any spots seen, at other times the solar surface shows many spots on an equatorial belt as wide as 60°. The sunspot cycle has an approximate period of 11 years. During the early part of the cycle, the spots appear at middle latitudes. But, later, they occur near the solar equator. The last sunspot minimum occurred in 1976 and we are now approaching the solar activity peak expected during 1980-81. Also observed is a reversal of the general magnetic field of the sun over a period of 22 years. The movement of sunspots across the solar disc indicates that the spots near the equator move faster than those in the higher latitudes.

Galileo inferred the rotation of the sun from the changing position of its spots. Observations have now established that the sun is in fact rotating faster at the equator than at the poles. The interaction of this differential rotation with the solar magnetic field is generally believed to be the basis of the solar cycle and the occurrence of sunspots. The equatorial regions of the sun, which rotate faster than the poles, distort the magnetic fields and amplify them in the azimuthal direction. Eventually, this bundle of lines of force becomes buoyant and emerges through the surface in the form of sunspots.

Such a model explains qualitatively most of the features of the solar cycle. But a *complete* qualitative model is awaited as there is the disturbing observation of Maunder that between the years 1645 and 1715 there were few or hardly any sunspots. John Eddy has checked this against historical records to show that auroras were absent during this period, and furthermore, the Maunder minimum was found to coincide with an extremely cold spell in Europe. Does it mean that we do not as yet have a proper understanding of the solar cycle? And could it be that the sun shuts off its activity from time to time?

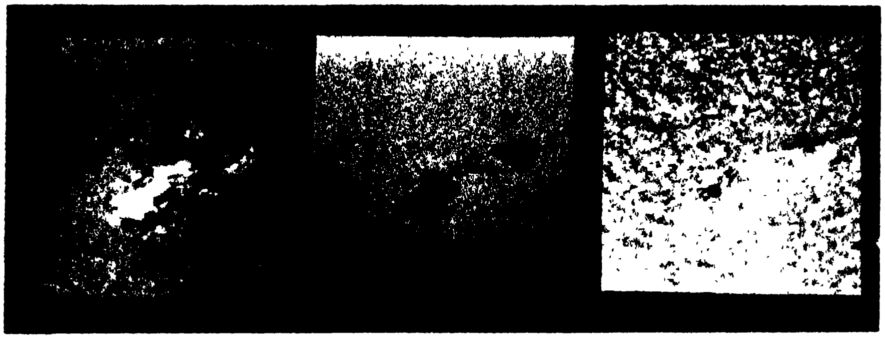
S.



Kitt Peak National Observatory

Magnetograms of the quiet sun of 26 January 1976 (left) and the active sun of 3 January 1978 (centre) are compared. On the right is the corresponding white light photograph of the active sun of 3 January 1978

The large sunspot group of 13 February 1978. The velocity map of the same sunspot group is coded in colour such that motion away from the observer is yellow, and towards the observer blue. For the magnetic fields of the same sunspot group, yellow is positive (north polarity) and blue magenta negative (south polarity)



Kitt Peak National Observatory

The Sun: Vital Statistics

Distance from earth.	1.496 million km
Luminosity	3 826 x 10^{33} ergs/second
Absolute visual magnitude	4.75
Spectral type	G2V
Diameter	1,392,000 km
Mass.	1 99 x 10^{33} gm
Average density	1.41 gm/cm^3
Core temperature.	15,000,000 °K
Photosphere temperature	5770° K
Rotation as seen from earth	25.38 days at the equator 33 days near the poles
Chemical composition	Hydrogen 71%) He (26.5%) and other elements (2.5%)
Age	About 5 billion years
Expected lifetime as a normal star	About 10 billion years

erated by the sun's magnetic field.

At the end of his book *Internal Constitution of the Stars,* written some 50 years ago, Sir Arthur Stanley Eddington stated "It is reasonable to hope that in the not-too-distant future we shall be competent to understand so simple a thing as a star." Over the past few decades, theoreticians have made considerable progress in unravelling the structure of the sun and other stars. The test provided by the neutrinos produced in the proton-proton chain to check the central temperature was attractive: As Bahcall wrote in 1967, "The use of a radically different observational probe may reveal wholly unexpected phenomena,... perhaps there is some great surprise in store for us when the first experiment in neutrino astronomy is completed." And, what was surprising, in Davis's neutrino experiment the count of neutrinos captured in the 100,000-gallon tank of washing fluid—perchloroethelene—turned out to be very low: a quarter of the number of neutrinos that would be expected from the proton–proton chain. This has embarrassed the theoreticians, who have been desperately trying to rescue their solar models with a host of ingenious proposals to explain the low counting rate. The possible explanations have ranged from a large magnetic field in the central regions to a rapidly rotating core and even a black hole at the centre.

An interesting possibility is that the sun does not always shine with the unvarying brightness we had imagined. It is conceivable that the sun is currently going through a phase when it is emitting fewer neutrinos because the nuclear reactions have been temporarily turned off in the interior. So, the sun should presently be shining with a brightness that is much reduced from the normal. Such changes in the solar luminosity should have profound consequences for the earth's climate.

The sun is part of the Milky Way, and if the solar system had been dissociated from the rest of the galaxy, the sun would perhaps have kept on shining with unchanging brightness. But, for the past five billion years, the solar system has been voyaging through varying cosmic environment. This is almost certain to have produced major changes in the physical conditions in the solar system. For better or for worse, such a situation is bound to affect significantly the evolution of life, especially the higher forms of life. Because, it may be that the origin and evolution of life here on earth are dependent on totally unsuspected factors which are present beyond our solar system.

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The solar corona

Arvind Bhatnagar

ONLY during fleeting moments of the total solar eclipse is the pearly white halo around the sun called corona visible to the naked eye. Normally, the intensely bright visible disc of the sun obscures the corona.

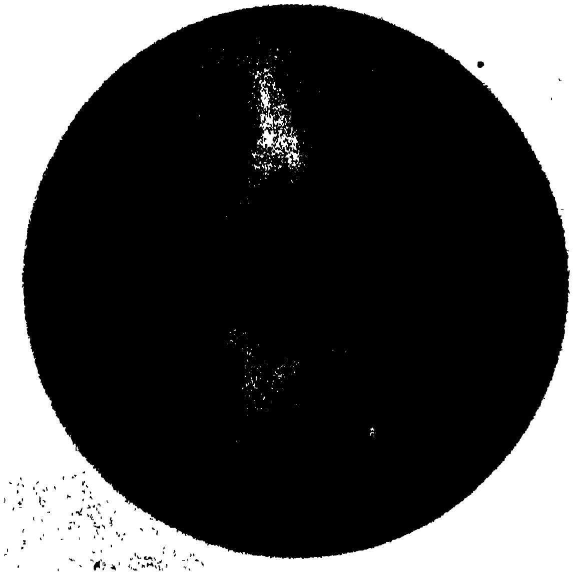
The corona has been observed during total solar eclipses for a long time, as is evident from Plutarch's comment on the solar eclipse of 27 December, 83. He wrote: "There always appears around the circumference of the moon some light that does not permit total darkness." But scientific studies of the corona have been carried out only during the last hundred years or so.

Coronal studies are important, for they give us information about the processes responsible for the outward flow of energy from the interior of the sun. Because of the extremely high temperature of the corona, it is like a plasma physics laboratory where interactions between high energy particles and magnetic fields can be observed. The outer parts of the corona extend to the earth, causing geomagnetic storms and changes in its atmosphere. The coronal studies have already helped us make useful forecasts of geomagnetic disturbances. Let us look at some of the results of coronal studies made during eclipses, using coronagraphs and instruments flown in spacecrafts.

Coronagraph

Since observations of the solar corona during eclipses are highly restricted in time, they do not give information about the dynamic changes taking place in it. In 1930, with great ingenuity the French astronomer, Bernard Lyot, built an optical device, giving extremely low instrumental scattered light, called the coronagraph. With coronagraphs, it has become possible to observe the inner corona of the sun from a few high altitude observatories on the earth. Lyot built a solar observatory in Pic du Midi in France to observe the coronal lines. Though important day-to-day details of the corona are observed with the help of coronagraphs, one of the drawbacks of this instrument is that only the inner bright corona extending to less than a solar diameter can be observed. During the total solar eclipse, one can see with the naked eye the faint coronal structural details even up to over four or five solar radii; this is because the moon occults the bright sunlight which otherwise gets scattered by the earth's atmosphere.

How does the corona look during an eclipse? The awesome corona is white and extends to about one solar diameter from the centre of the solar disc, that is, about 1.4 million km. It is a very complex structure. It has long radiating rays called streamers, streaks called polar plumes and structures called helmets. The white colour of the corona is actually due to the white light from the visible solar photosphere that has been scattered by the free electrons in the corona. The electrons scatter light without changing its colour. The distribution of electrons around the sun is shaped by the magnetic field lines in the corona. Thus the study of the structure of the corona gives information about the coronal magnetic fields.



Sky and Telescope

The elusive corona is seen without a total solar eclipse with the help of a coronagraph telescope on the Skylab The coronagraph helps to simulate an eclipse. The comet Kohoutek is seen bottom right as it swings past the sun

Coronal streamers lie over the active regions in the photosphere. They are shaped like tulip bulbs or flower petals with the pointed, long ends stretching out away from the sun. The streamers extend out to more than four or five solar radii from the sun. Helmets are spade-shaped coronal structures overlying quiescent prominences. They are not as long as the streamers, being usually confined to about one solar diameter from the visible surface of the sun. Solar plumes are small, thin, cylindrical features usually present at higher latitudes (greater than 70°). They resemble patterns of iron filings about the poles of a bar magnet. In fact, the similarity between the two led astronomers to look for the general magnetic field on the sun.

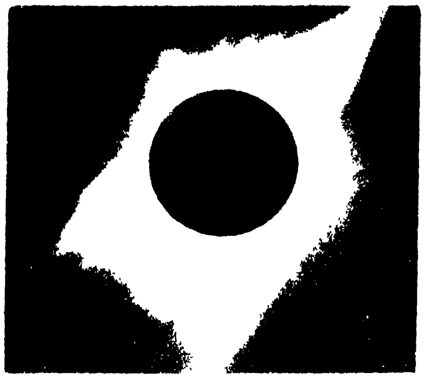
Corona and the sunspot cycle

Observations and photographs of the corona during many eclipses show that the coronal form changes from eclipse to eclipse and depends on the 11-year sunspot cycle. When the sunspots are maximum in number, the corona appears to be spherically symmetric around the sun. The isophotes, that is, the contours of equal brightness, are nearly circular in the corona at this time. It is so crowded with plumes, streamers and helmets that very few features can be distinguished. When the sunspots are minimum, the corona is more elliptical and less bright. The streamers are distributed more or less along the equator (because during minimum, the sunspot activity is almost confined to the equatorial regions of the sun).

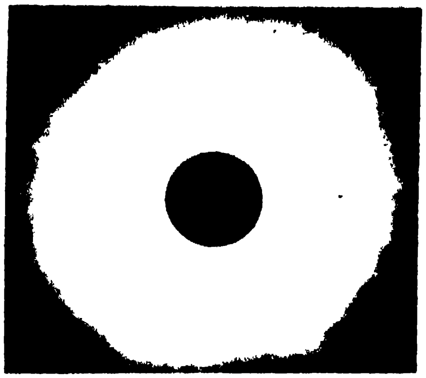
The 1980 eclipse will occur during the maximum of the solar cycle. From past observations of sunspot cycles, it is believed that the present cycle, numbered 21, will have one of the four highest maxima since the beginning of the 19th century, so the corona seen during the eclipse will tend to be more globular in shape and brighter than the corona observed during previous eclipses at sunspot maximum periods.

Spectrum of the corona

It is well known that the visible white light from the sun is made up of a continuum of colours such as violet, indigo, blue, green, yellow, orange and red. Superimposed on this continuum are hundreds of dark lines called the Fraunhofer lines. Each line



The shape of the corona near sunspot minimum (Yerkes Observatory photograph)



The shape of the corona near sunspot maximum (Yerkes Observatory photograph)

is a signature of an element present in the solar atmosphere and gives information about the state of ionisation of the element. The intensity and width of lines reveal the temperature and density of the elements. The position of lines and polarisation give information about the magnetic field strengths and mass motion on the surface of the sun. So what does the spectrum of the corona look like? The American scientist, Charles Young, was the first to see the spectrum of the corona during the solar eclipse on 7 August 1869. It consists of three parts, called the E or the emission corona, the K-corona and the F-corona.

The spectrum of the inner corona shows a continuum of colours crossed by faint emission lines. The coronal continuum is a few millionth of the photospheric brightness and the coronal emission lines may be about 50 to 100 times brighter than the coronal continuum. These emission lines constitute the E-corona. For nearly 70 years, these lines defied explanation. Only in 1940, following developments in atomic theory and spectroscopy, it was realised that they are due to the presence of highly ionised atoms around the sun. This convinced solar astronomers that the corona has a very high temperature (of a million degrees or more), but a low density. These lines are called the forbidden lines, because, under terrestrial conditions, the probability of emission at these wavelengths is low. But such emissions are possible at the high temperature and low density conditions in the solar corona.

The high temperature of corona was, in fact, very puzzling; contrary to the common experience of feeling less heat as one moves away from a radiating surface, the temperature of the corona rises sharply as the distance from the photosphere increases. Because of the high temperature and the low density of the corona, atoms in it are stripped of almost half of their electrons. One of the aims of all eclipse expeditions has been to identify the lines and the variation in their brightness as a function of distance from the photosphere and with the 11-year sunspot cycle. Variations in the line strength with respect to the zones of solar activity have also been examined. The brightest and the well-known emission line is the green coronal line which is emitted by iron atoms, stripped of 13 of their 25 orbital electrons.

The K-corona is the continuum associated with the E-lines and is due to the photospheric light scattered by free electrons in the corona. It derives its name from the German word 'kontinuum'. Because of the high temperature of the corona, the electrons move so fast that the light scattered by them is Doppler-shifted. As a result, the original Fraunhofer lines of the photosphere are smeared and thus become indistinguishable. The K-corona is dominant up to a distance of about one solar diameter; beyond, it becomes weaker. It is strongly polarised.

In the outer corona, that is, at a distance of about one solar diameter, the K-corona, which gradually becomes faint as it moves away from the limb of the sun, is reinforced by the F-corona. The F-corona shows all the Fraunhofer absorption lines and no polarisation. This is due to the scattering of sunlight by solid particles between the sun and the earth, and is physically not linked with the sun. Measurements show that the F-corona is simply the extension of the zodiacal light, that is, the occasional faint glow at the horizon seen before sunrise in the eastern sky or after sunset in the western sky. The K- and F-coronas extend out into the interplanetary space and even envelope the earth, though they are extremely weak at this distance. In a sense, we are living in the sun's extended atmosphere.

The separation of the three components of the corona and the determination of the electron density and temperature are obtained from the spectroscopic, polarisation and direct photographic observations made during the total eclipse. The temperature in the corona may range from 1 to 3 million degrees Kelvin and electron concentrations from less than several thousand to more than 500,000,000 per cubic centimetre, depending on the solar activity and the distance from the photosphere.

Observations with rockets

Because of the high temperature of the corona, it emits strong radiations in the ultraviolet and x-ray regions. Since the radiation in this part of the spectrum is absorbed by the earth's atmosphere, observations have to be made above the earth's atmosphere with the help of rockets and satellites. The photosphere, being at a lower temperature, radiates very weakly in this part of the spectrum. Most of the radiation, however, comes from the corona, unlike the situation in visible light where the photosphere radiates strongly. From the ultraviolet spectrum of the sun, new emission lines originating in the corona have been identified.

At x-ray wavelengths, the underlying photosphere and chromosphere are not seen only the corona, is seen. Also, the corona can be observed in x-rays all the time from spacecrafts with or without a total solar eclipse.

In x-rays, dark features have been seen on the surface of the sun. These are called coronal holes and are regions of low density and temperature. The coronal holes extend to the poles of the sun and sometimes even stretch down towards the solar equatorial regions, thus covering large areas of the sun. The magnetic field lines within the coronal holes are known to stretch radially outwards from the sun. Also, high-speed solar wind particles are associated with them. Because of the high temperature and the pressure gradient, the solar corona is not in hydrostatic equilibrium but keeps expanding away from the sun.

Though solar wind particles are able to escape from coronal holes, elsewhere they are trapped by the closed magnetic field lines. The solar magnetic field is also sometimes pulled away from the sun with the particle stream. This gives rise to the interplanetary field. The solar particle stream and magnetic fields affect the earth's magnetic fields. Solar wind particles and radiation pressure affect the tails of comets. And, as seen from comet photographs, the tail is always directed away from the sun.

In x-ray observations of the sun, small bright points have been observed which are associated with the small bipolar photospheric magnetic regions. Further, in the polar regions of the sun, the coronal polar plumes seen during the total eclipse could be traced back to bright points on the solar surface. This means that polar plumes originate from strong magnetic field regions.

Coronagraphs have been flown in spacecrafts also for synoptic continuous observations of the corona. Extremely useful results were obtained by the Skylab spacecraft, which observed coronal disturbances travelling at over 200 to 400 km per second out to several tens of solar radii; these are known as coronal transients. Effects of these disturbances could be felt even beyond the orbit of the planet Jupiter. A worldwide co-operative study will be undertaken during the current sunspot maximum year (1979-81) to observe coronal transients from space and associated activity on the sun.

Astronomers prepare for months and years making special equipment depending on the type of investigation to be made during the eclipse. For optical observations, generally, refracting telescopes are pointed towards the sun, or the sunlight is diverted by means of a heliostat to a refracting or a reflecting telescope This may, in turn, focus the eclipsed sun on a photographic plate for taking pictures of the solar corona, or for polarisation measurements through polaroids, or to spectrographs for taking spectra of the corona and the "Flash" spectrum.

To study the ultraviolet spectrum of the solar chromosphere, which is normally inaccessible from the earth, even rockets, carrying proper instruments, are launched during the total eclipse. Astronomers have even raced along the path of the eclipse in high-flying aircraft with telescopes in order to lengthen the observational period of the totality.

Radio radiations emitted from the sun are observed during the eclipse too. Measurements in the millimetre and centimetre wavelengths may reveal the fine structure of the emitting regions on the sun as the moon's disc progressively occults the sun.

During the 1980 total eclipse, a number of experiments will be conducted to make new determinations of the electron density, polarisation and temperature of the solar corona and to study their variations with the solar cycle. A large number of Indian and foreign professional and amateur astronomers are expected to conduct valuable experiments.

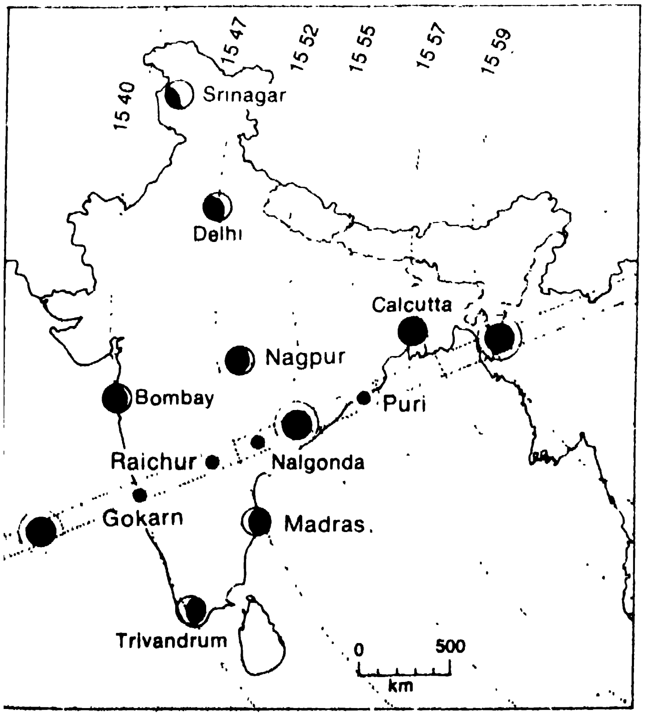
Some of the studies to be conducted by Indian astronomers during the total eclipse are: (1) study of the coronal spectrum, (2) study of the corona with Fabry-Perot Etalon, (3) study of the coronal velocity field, (4) study of the polarisation of the corona, (5) study of the Flash spectrum, (6) measurement of the deflection of light by the sun's gravitational field, (7) cinematography of solar eclipse and the Flash spectrum, (8) studies of radio emissions in the centimetre and millimetre range, (9) ionosphere drifts and irregularities during the total eclipse, (10) coronal intensity distribution, and (11) search for chromospheric lines in the hot coronal spectrum.

Dr Bhatnagar is the director of Vedhshala Udaipur Solar Observatory He worked for his doctorate in solar physics in Kodaikanal Observatory before taking the Carnegie fellowship at the Mount Wilson and Palomar obser-vetories, California, USA He was also research scientist at the Kitt Peak National Observatory and California Institute of Technology On returning to India, he established a solar observatory in the middle of the Fatehsagar lake in Udaipur This observatory has already contributed significant solar observational data

An eclipse watcher's guide

A. Bhatnagar, N.C. Rana and Jyoti Nevatia

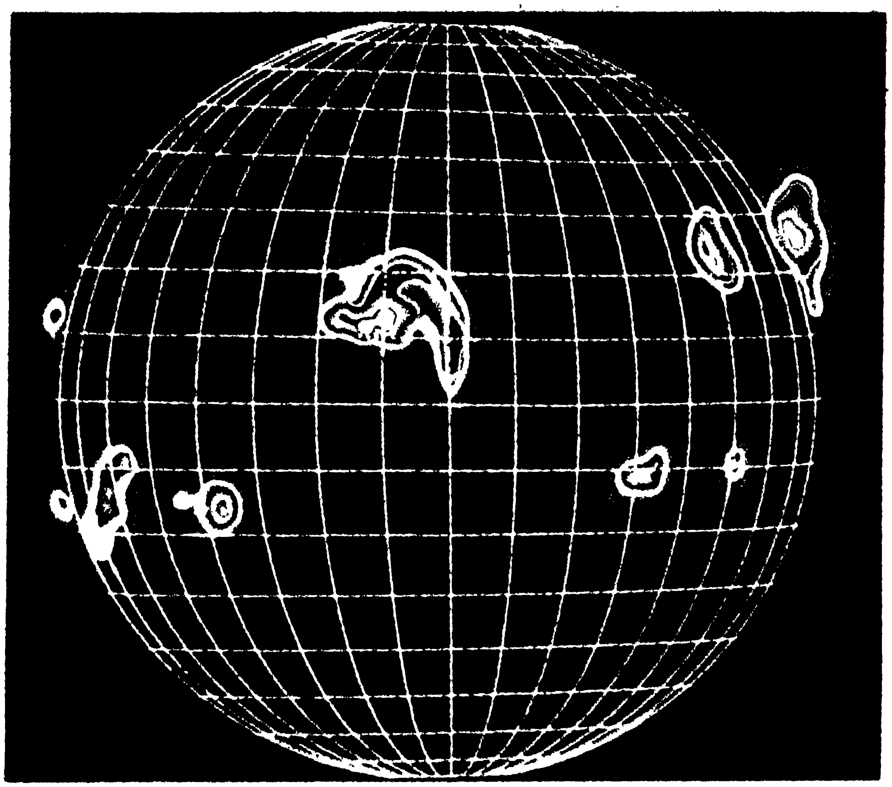
Never, never look at the partially eclipsed sun with the naked eye



Total eclipse of 16 February 1980 in India The map shows the timings in IST of the minimum phase and percentage of the sun's disc covered The dark strip indicates the zone of totality

After about 82 years, a total solar eclipse will be visible again under favourable weather conditions on 16 February 1980, from a strip of thickly populated subterrain in India. The map of India shows the places from where this eclipse would be seen. Since most of us will be seeing such an event for the first time, it may be useful to get acquainted with the track of the eclipse, how to observe it and what to look for in the sky and on the ground during this time.

The path of totality, which is only about 130 km wide at its point of entrance near Ankola in Maharashtra on the western coast, will head almost straight towards the eastern coast at Puri in Orissa with an increasing speed but a diminishing width (Table 1). Crossing the Bay of Bengal, it will pass over the southern part of Bangladesh, Burma, Mizoram in India, and south China where the shadow will leave the earth with the queer spectacle of a haloed sunset (see world map). At any instant, the duration of the totality is the maximum on the central line. But the maximum duration is itself so short that nowhere



Photograph of the sun in hard X-rays taken by Skylab above the earth's atmosphere. The X-ray emission has been colour contoured and latitude and longitude lines have been added to facilitate the comparison with other solar data such as sunspots. The brightest coronal emission is coloured white, and corresponds to temperatures in excess of 5×10^6 K. Top is north and left is east.

in India does it exceed the highest period of 2 minutes and 50 seconds that it will achieve on the western coast. The Japal-Rangapur optical observatory near Hyderabad will observe 104 per cent eclipse, while the radio astronomy observatory at Ooty will see 89 per cent of the sun covered.

To make good use of these precious moments, several professional and amateur astronomers in India are already well prepared with necessary equipments as well as with a thorough scheme of sequential operations. Since it will be February, the sky is expected to be free from clouds in India in the path of totality. Also, as the totality over India will continue from 1540 hours (3-40 pm IST) to about a minute past 1600 hours (4 pm IST) the view will not be hindered by buildings and trees. The sun will remain well above the horizon.

A good site for astronomical observation has to be very close to the path of mid-totality (preferably within 13 to 16 km). The farther north or south one goes from this line, the faster is the rate at which the duration diminishes: halfway from the mid-line to the border of the path of totality, the duration of totality is reduced by about 13 per cent; three-quarters from the mid-line, it is reduced by about 34 per cent; and at a distance of nine-tenths from the midline, the duration is further reduced to 43 per cent.

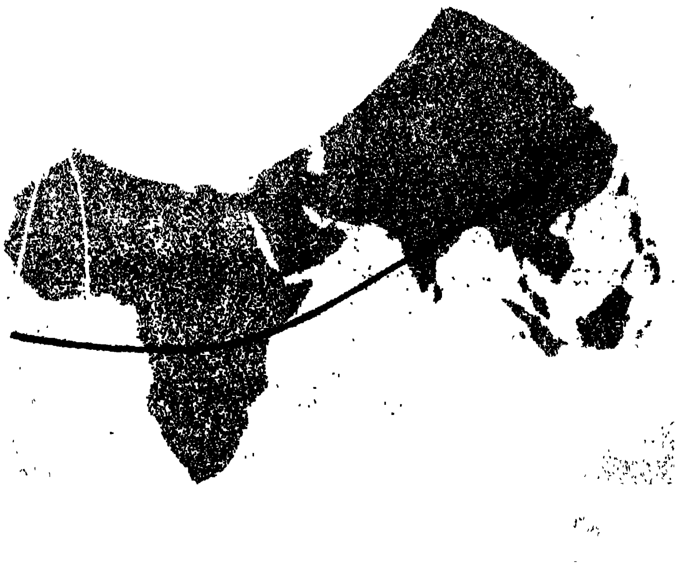
The site should also be so chosen that, meteorologically, one could expect a dry and calm day with no overcast sky. The expected day temperature should be preferably around 25°C, relative humidity less than 50 per cent, and wind velocity less than 10 km per second. Obviously, an off-shore but relatively high altitude place will, in addition, offer reduced sky brightness and minimal seeing effects. The relevant meteorological data for a few typical places falling on the path of totality are given in Table 2.

For delicate astronomical observations, the place chosen should be at least 13 to 16 km away from the main city to avoid crowds of onlookers, road and railway traffic disturbances, microwave lines, smoky and dusty industrial surroundings and, possibly, seismic disturbances produced by heavy plants and workshops.

For studying some of the least understood phenomena like shadow-bands, a slightly slopy site would be preferable. A very wide and open landscape should come directly under the observer's field of view, with a downward slope on the west and an upward slope on the east. Again, the seashore is not a good place for studying shadow-bands. Those who want to study the effects of the total solar eclipse on animal, plant and human behaviour should select appropriate sites.

How to watch

Despite the superstitious beliefs, it is harmless to see the sun during a total eclipse, since the normally intense light from the sun is blocked



Map shows the narrow path of totality and the much larger areas of partial eclipse. Totality begins in the central Atlantic ocean at sunrise (1242 IST), and ends at sunset (1641 IST) in Szechwan province, China, the shadow travelling nearly 14,000 km. The maximum duration of totality will be 4 min 12.4 sec in the Indian Ocean

Time lapse sequence exposure every few minutes onto a single frame of the partial phases and totality

by the moon. But before and after totality, the sun should not be looked at directly; one can either look at the sun's image on a screen formed by rays passing through a pinhole in front, or see the sun through a suitable filter. Even with filters, one shouldn't look at an eclipse for a long time.

The safest method is to watch a projected image of the sun. This way, one can literally turn one's back to the sun and avoid the temptation of looking during the partial phase. Take a stiff cardboard of about 30 x 30 cm size, make a square or round hole of 2 or 3 cm diameter in it and cover this with an aluminium foil; even the foil from a cigarette packet will do. Stretch the foil and stick it on the cardboard hole and make a small sharp pinhole. Take a piece of white cardboard, or better still a white-painted wall facing the south-west direction, which will form the projection screen. Now hold the pinhole cardboard at an arm's length. You will get a pinhole image of the sun on the wall, or the white cardboard. This "simple projection telescope" provides the safest means to watch solar eclipse. Pinhole images of the partial phase are also formed on the ground by gaps in tree leaves and give an interesting view of the crescent sun.

Two fully developed black-and-white negative films which are totally black could also be used to view the partial phases of the eclipse, but this kind of filter is good only for a short time. The use of soot-blackened glass plate is not safe. Aluminised mylar plastic sheet is considered a safe filter. Since at least 95 per cent of the sunlight is reflected by the aluminised surface, only a small amount of sunlight passes through the mylar sheet making the viewing quite safe. One can also look at the sun's image at the bottom of a surface filled with water to which a little cowdung or turmeric powder has been added.

Viewing through binoculars and telescopes

Binoculars and telescopes will indeed give a magnified image of the Baily's beads, prominences and the corona. But it will be better to use low-power binoculars. This will show the splendour of the whole event rather than magnify tiny parts of it. For an overall view, however, the naked eye is still the best.

The binocular needs to be mounted firmly, so fix it on a tripod or place it on a pile of bricks. There are two ways of looking at the sun with binoculars. One is where one of the object glasses of the binocular is covered and the eyepiece is raked out beyond the normal position. A white screen is held a foot or so behind the eyepiece and the sun's image is focussed on it. A cardboard sheet is put in front of the screen to shade the projection screen to avoid a diffused image. To project the sun, the binocular is aligned with the sun by looking at it's shadow on the ground. When the shadow of the instrument is the smallest, the white screen is kept behind the eyepiece and the image focussed.

In the second method, filters are used. The overexposed and densely fogged negatives make excellent filters. Two discs of such films are mounted inside cardboard caps which can be slipped on and off the object glasses. Or one can cover the object lenses with aluminium-metallised plastic sheets.

If thick, dark green glass filters (to decrease sunlight by 10,000 times to observe partial phases) are used, they may be kept in front of the object lenses and not behind the eyepiece. The intense light from the sun may cause the glass to expand and shatter if it is placed at the focus of the binocular. Besides, the glass separates the eye from the eyepiece and restricts the field of view.

Binoculars are cheap and portable compared to telescopes. You can also use a wide-angle telescope for your first eclipse.

Table 2:
Meteorological data for the month of February

Station	Honavar	Raichur	Hyderabad
Latitude	14°17′N	16°12′N	17°27′N
Longitude	74°27′E	77°21′E	78°28′E
Height (above mear sea level)	26 m	400 m	545 m
Relative humidity			
Morning	75%	54%	64%
Evening	64%	29%	35%
Temperature			
Min	21°C	20°C	17°C
Max	31°C	33°C	31°C
Rainfall			
No.of rainy days	0 0	0 6	0.8
Monthly total	0 1 mm	6 0 mm	11 4 mm
Wind velocity	5 2 km/h	9 4 km/h	8.9 km/h
Days of clear sky	7 days	12 days	9 days
Days of overcast skies	0 0 day	0.0 day	0.0 day
Cloudiness in octas (all types)	2.4	2 1	2.1

Table 1: **Eclipse data for certain places in India**

Place	Partial eclipse begins (IST)	Total eclipse begins (IST)	Total eclipse ends (IST)	Partial eclipse ends (IST)	Duration of totality at the nearest point on the central line	Altitude of the sun	Width of the shadow path (in km)	Speed of the shadow km/min
Gokarn	$14^h\ 17^m$	$15^h\ 38^m\ 33^s$	$15^h\ 41^m\ 25^s$	$16^h\ 52^m$	$2^m\ 51\ 8^s$	39°	128	68
Honavar	$14^h\ 18^m$	$15^h\ 39^m\ 00^s$	$15^h\ 41^m\ 09^s$	$16^h\ 52^m$	$2^m\ 51.8^s$	39°	128	68
Raichur	$14^h\ 25^m$	$15^h\ 43^m\ 40^s$	$15^h\ 46^m\ 22^s$	$16^h\ 55^m$	$2^m\ 41\ 5^s$	35°	125	80 8
Nalgonda	$14^h\ 30^m$	$15^h\ 46^m\ 25^s$	$15^h\ 49^m\ 01^s$	$16^h\ 56^m$	$2^m\ 35.6^s$	32°	122	88
Berhampur	$14^h\ 40^m$	$15^h\ 52^m\ 55^s$	$15^h\ 55^m\ 15^s$	$16^h\ 59^m$	$2^m\ 19\ 9^s$	25°	116	113 6
Puri	$14^h\ 42^m$	$15^h\ 53^m\ 56^s$	$15^h\ 56^m\ 12^s$	$17^h\ 00^m$	$2^m\ 17.0^s$	24°	115	121 6

Try to set your equipment by aiming at the sun 24 hours early. This way you will not be wasting precious time during the eclipse. Mark the position of the platform clearly, and clean the eyepiece, object glass and filters.

Early 17th-century observation of a solar eclipse by projection in a darkened room The Polish astronomer Hevelius is seen marking the crescent of the sun

Professionals, of course, will go on this expedition, with their own predetermined objectives, but amateur astronomers may choose some of the following observational assignments: (a) the records of the shadow-bands (they will certainly be helpful for a proper understanding of this phenomenon); (b) changes in behaviour of plants like algae, tamarind, mimosa, etc, insects like grasshoppers and bees, and some birds and animals, including dogs and lizards (the main objective is to study the effects of the eclipsed sun on biological functioning, for example photosynthesis, hormonal secretions, etc); (c) accurate timings of the beginning and the end of totality (to know the shortcomings in the prediction of eclipses; in fact, the gradual slowing down of the earth's axial rotation and the precise position of the moon can be known accurately from such discrepancies); (d) photographs of the solar corona, the chromosphere, the diamond rings, Baily's beads, etc (details of the photography have been discussed in the following article); (e) changes in temperature, pressure, intensity of light and colour of the sky and landscape along the path of the moon's shadow; (f) spectroscopic observations of the "Flash" spectrum, prominences and the corona, followed by accurate freehand drawing of the coronal structure, as the eye, because of its large dynamic range, can see more than what a photographic plate or film can record.

Let us consider details of the sequence of the phenomena in the sky during the eclipse. As the moon's shadow approaches from the west and makes the first contact with the solar disc, it marks the beginning of the solar eclipse. This first contact is hardly noticeable, but, within a few seconds, one sees the sun sliced. For the next hour or so, the moon's dark disc is seen advancing across the sun, displaying the partial phases of the eclipse. In the zone of total solar eclipse, sunlight will weaken and a pale, lemon yellow colour may develop before the face of the sun is totally covered. Just then, as the moon covers the sun, the last beam of light breaks through the moon's valleys forming a beaded necklace along the edge of the moon; this is called the Baily's beads It is expected that there will be a low place called Mare Orientale on the moon near the limb of the sun during the second contact (beginning of totality), and another large one near Mare Smythi during the third contact (end of totality), which should be able to provide beautiful and stunning diamond rings.

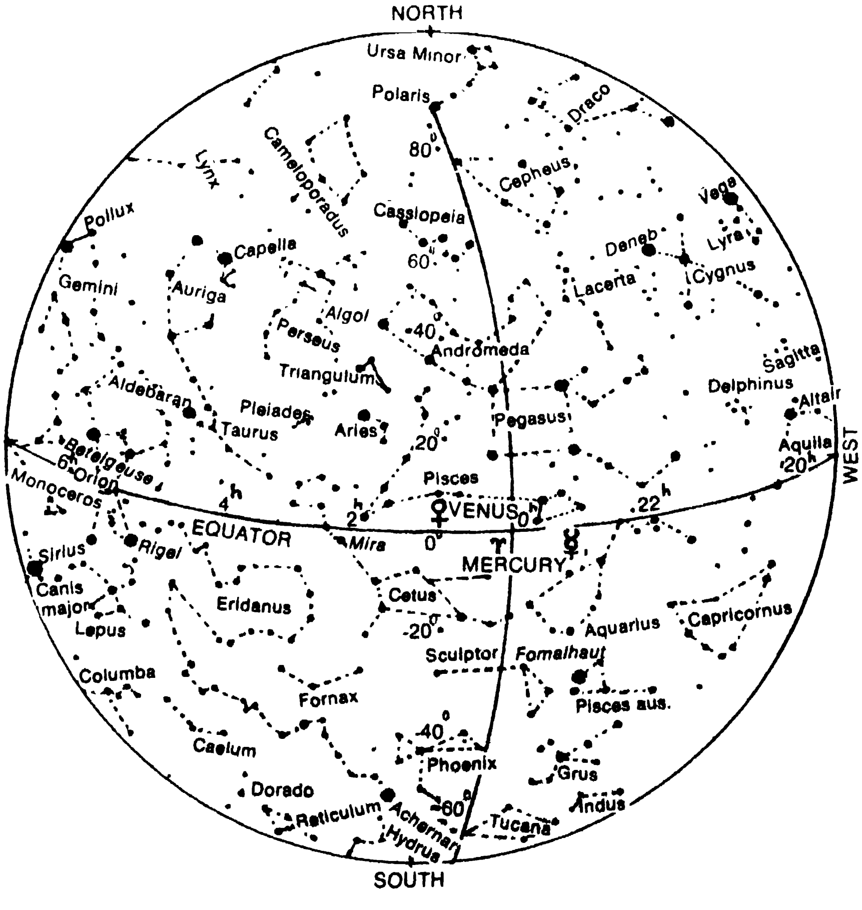
During totality an instant later, the sun will have gone out of view and a strange darkness will fall on the earth. In place of the sun, there will be a black spot in the dark sky, surrounded by a soft pearly bluish light, almost as bright as the full moon but 100,000 times fainter than the sun. This is the solar corona. It extends outwards, several times the diameter of the sun. The bright stars and the planets will suddenly appear. You will probably notice that the faint light from the corona is not uniformly distributed around the eclipsed sun, but spiky rays are stretched far out into the sky. Make a mental note of the irregular distribution and extension of the corona in terms of the diameter of the sun; a quick sketch will help you to remember them later.

Looking carefully at the black edge of the moon's disc (during the totality phase), you may notice a few bright points or regions of pink light, extending beyond the edge; these are the solar prominences. Sometimes these prominences show violent motion as the solar material is thrown out at a great speed, like tongues of flame. If you are lucky, you may see a large solar prominence during the 1980 eclipse.

After about two-and-a-half minutes of totality, suddenly another dazzling diamond ring will herald the emergence of the sun from behind the moon. A silver crescent of sunlight replaces the diamond. And as the corona suddenly disappears and daylight gradually grows once again, the total eclipse of 1980 will become history.

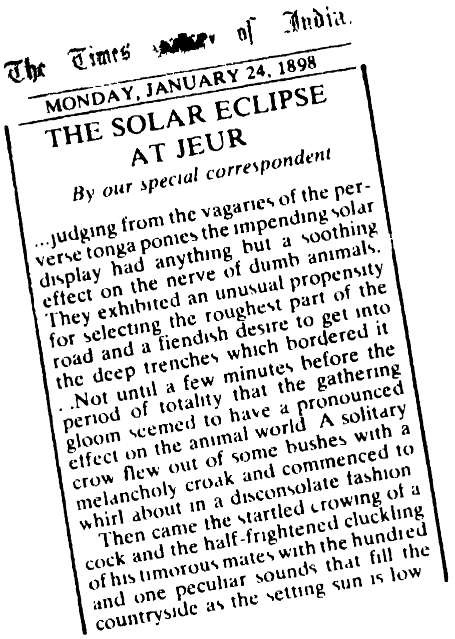
During totality, bright stars and

The sky over Nalgonda, Andhra Pradesh, during totality



some of the planets become visible with unaided eyes. Around the eclipsed sun, there emerges the hitherto unseen solar corona. Its total brightness depends on the phase of solar activity, so the corona is expected to be approximately as bright as the moon seen on the eleventh day of its waxing phase (*Shukla Ekadasi tithi*).

A typical skymap during mid-totality (at 1548 IST on 16 February 1980) for Nalgonda (about 50 km south of Hyderabad) is given. All stars up to 4.5 magnitudes are shown. The positions of the eclipsed sun near the constellation Aquarius, the planets Mercury and Venus, the moon's path, the celestial equator, the ecliptic (the sun's path), the descending node (the point where the moon crosses the ecliptic from north to south) and the Milky Way are also shown (one of the authors, N.C. Rana, has developed a computer graphics programme for generating such a skymap for any place on the earth and for any time of the day and the year).



The Times of India.

MONDAY, JANUARY 24, 1898

THE SOLAR ECLIPSE AT JEUR

By our special correspondent

...judging from the vagaries of the perverse tonga ponies the impending solar display had anything but a soothing effect on the nerve of dumb animals. They exhibited an unusual propensity for selecting the roughest part of the road and a fiendish desire to get into the deep trenches which bordered it ..Not until a few minutes before the period of totality that the gathering gloom seemed to have a pronounced effect on the animal world A solitary crow flew out of some bushes with a melancholy croak and commenced to whirl about in a disconsolate fashion

Then came the startled crowing of a cock and the half-frightened cluckling of his timorous mates with the hundred and one peculiar sounds that fill the countryside as the setting sun is low

There are quite a few prominent variable stars in the sky. During this total solar eclipse, Mira, the brightest star of the constellation Cetus, will be barely visible while Algol, another prominent eclipsing variable star belonging to the constellation Perseus will be seen with its normal apparent brightness. Some bright stars like Sirius, Betelgeuse, Rigel, Achernar, Aldebaran, Capella, Hamal, Fomalhaut, Deneb, Altair and possibly Vega will appear distinctly above the horizon.

Spectrographic observations

The simplest spectroscopic observation, and one of considerable scientific significance, that an amateur astronomer can make is to photograph the "Flash" spectrum. A simple prism or a transmission grating can be placed in front of a telephoto lens-camera arrangement. The thin crescent of the eclipsed sun acts as the slit of the spectrograph. A spectrum thus obtained will be a series of arcs, formed by the emission lines of the chromosphere. From the length of the arcs, one determines the height of the formation of the lines.

To obtain the spectrum of the corona, one needs a stable telescope and spectrograph arrangement for recording fairly long exposures for a few seconds.

There will be two more total solar eclipses in this century, which will be visible from the northern parts of India. One of them will be on 24 October 1995 (*Diwali*) and the other on 11 August 1999. But weather conditions may cause some problems in observing them. If we miss them, the next one to be visible from India will not be before 3 September, 2081.

Mr Rana is with the Tata Institute of Fundamental Research, Bombay.

Dr Nevatia is on the editorial staff of SCIENCE TODAY

Shoot the eclipse !

THE FEBRUARY eclipse will afford a good opportunity for photography since the sun at eclipse time will be at a convenient elevation in the sky and since the total phase itself will last for over two minutes.

Any amateur can take interesting photographs even with the simplest camera. But a word of caution first. Eclipse watchers will have an irresistible temptation to keep their eyes fixed on the sun, in spite of its brightness. While viewing the sun, always cut down the light with a smoked-glass plate or other device, and never look directly at the sun through your camera or other optical instrument. If your camera has a non-metallic focal plane shutter, see that you cut down the light sufficiently before you focus directly.

To keep your camera or telescope steady (since long exposures are required in certain cases) make sure you use a rigid tripod. If you don't have one, a firm table or stool with a few small wooden blocks below for any necessary tilt would do as well.

Cameras and telescopes

A good three-inch refractor or a six inch reflector telescope is good enough for solar image projection or for direct through-the-telescope photography. Tracking is not essential, unless the image is very large and the exposures very low. But keep in mind that the higher the magnification, the quicker will the solar image move across the field of view.

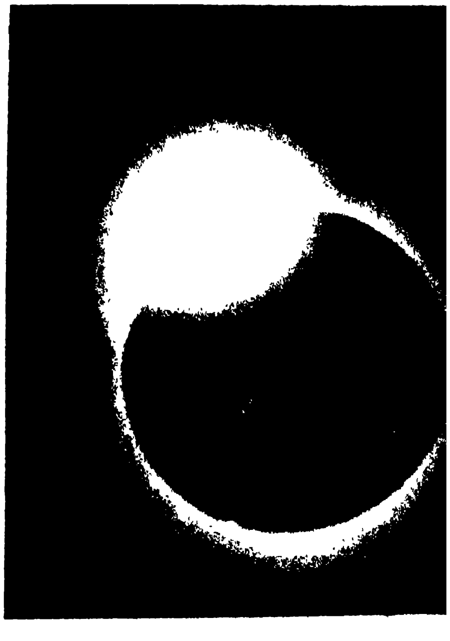
What camera will you use? If yours is a 35 mm single-lens reflex (SLR) with interchangeable lenses, exposure indicator and shutter speeds from "B" to 1/500 or 1/1,000 sec, you will find it very suitable for direct shots. Always use a cable release cord to minimise camera movement. Even if you possess only a simple fixed-lens camera, a little ingenuity can help you overcome your limitations: get your image size and focus confirmed before you load the film by holding a ground-glass plate or piece of tracing paper at the film plane with the camera's back open.

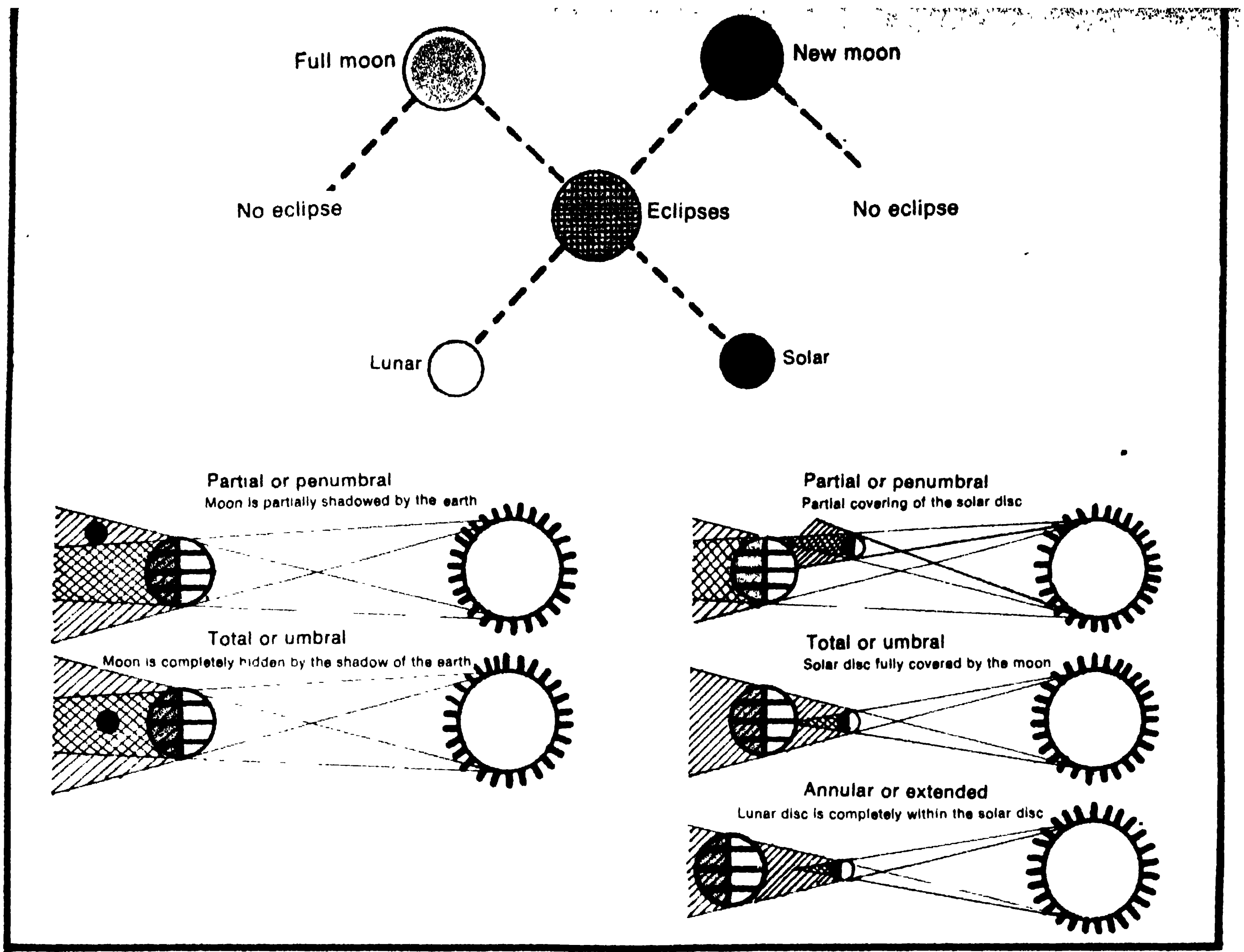
Note that the apparent diameter and intensity of the sun varies from month to month and according to the time of the day. As a rough guide, lenses of focal lengths 50, 350 and 1,000 mm will give primary solar disc images with diameters of 0.5, 3.5 and 9 mm, respectively.

Films and filters

Since the partial phases of the eclipse are highly intense, a slow (about 100 ASA) fine-grain film would be the best for both colour and

Celestial diamond ring · The sunlight sparkling through a huge lunar valley produces what is called the diamondring effect




Full moon
New moon
No eclipse
Eclipses
No eclipse
Lunar
Solar
Partial or penumbral
Moon is partially shadowed by the earth
Total or umbral
Moon is completely hidden by the shadow of the earth
Partial or penumbral
Partial covering of the solar disc
Total or umbral
Solar disc fully covered by the moon
Annular or extended
Lunar disc is completely within the solar disc

Eclipse means to throw into the shade, to hide wholly or in part

The moon's orbit around the earth is very close to the plane of the earth's orbit around the sun and both these orbits are elliptical When the moon is between the sun and the earth, and is not seen rom the earth, it is called the new moon Full moon is when the earth is between the sun and the moon However, if all these three celestial bodies are more or less in the same straight line, eclipses occur Solar eclipses occur during the new moon and the lunar clipses during the full moon Again, if the centres of the three odies are almost along a straight line, then total (umbral) eclipses take place. If any one of the centres of the three is slightly away, the partial (penumbral) eclipses occur

Umbra is the region where there is no direct sunlight due to the shadow of the intervening body Penumbra is that region where certain amount of direct sunlight falls

When the moon is close to the earth it appears larger and, at eclipse, fully blocks out the sun This is a total eclipse. The distances between the three bodies vary at different times. When the moon is more distant from the earth, it is too small to cover the sun entirely at eclipse. When this happens, an annulus (ring) of the sun is seen surrounding the moon.

black-and-white prints or transparencies. Films even slower than that, although better for full disc to partial phases, may be too slow for the totality phase or when used with very narrow-band filters.

Narrow-band filters transmit only a narrow range of wavelengths (colours) centred about the hydrogen red line emitted by the sun. These, as also paired Polaroid and mylar filters are not only expensive, but also not easily available in India. Easy, inexpensive substitutes for them are the neutral density filters, smoked-glass plates, uniformly exposed x-ray or negative (black and white or colour) films, semi-transparent glass plates (silver or aluminium coated), or even a lens from a pair of welder's goggles. Only, take a few trial photographs of the sun in advance to make sure your "filter" isn't going to spoil your picture.

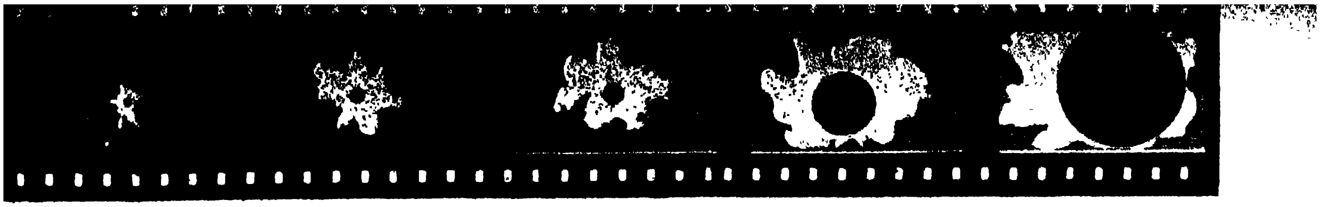
It is best to place filters *ahead* of the objective lens in the normal manner, covering the camera's full aperture. On the other hand, if it is kept near the focal plane, not only the intense heat may damage the filter, but the searing focussed light may harm the shutter and the film, even the retina of your eye! Check all filters for scratches and tears and for its optical quality.

What to catch

The main glory of a total eclipse lies in the view of the "pearly" corona. The intensity at totality will have dropped considerably, so the filters should be removed. Just before second contact the "diamond ring" and "Baily's beads" flash into view. At mid-totality the silvery corona is at its

The sunlight peeping through the valleys and crags around the rim of the moon produces pearly bright spots called Baily's beads (marked with an arrow above)

Sky and Telescope



The use of different lenses will give different image sizes

best. The corona's intensity varies tremendously decreasing outwards. Try and capture the intricate brush-like tufts of the inner corona and see if they bear any relation to the sunspot group position. Colour film would capture the beautiful tints and hues at this stage. An approximate exposure guide is given below. Starting with very short exposures of the partial stages, the exposure time is slowly increased as more and more of the sun's disc is covered. After totality the sequence reverses.

Four popular experimental set-ups are discussed below:

Use these exposure settings as a guide

Film Speed ASA	f/ratio of optical system					
25	1.4	2	2.8	4	5.6	8
50	2	2.8	4	5.6	8	11
100	2.8	4	5.6	8	11	16
200	4	5.6	8	11	16	22
400	5.6	8	11	16	22	32
Feature of Interest						
Prominences	—	1/1000	1/500	1/250	1/125	1/60
Inner Corona	1/1000	1/500	1/250	1/125	1/60	1/30
Middle Corona	1/60	1/30	1/15	1/8	1/4	1/2
Outer Corona	1/8	1/4	1/2	1	2	4
Extreme Corona	1	2	4	8	16	32

(Exposure in seconds)

1. *Direct camera with fixed, standard lens and filter.* Since the solar image is small in this case, one can take a single-frame, multiple-exposure picture of the full sequence. Remember that the sun subtends an angle of about 1/2° in the sky and so its image will move across the film frame at a rate equal to its diameter in two minutes. Try the following procedure. With the camera in "B" position (with Click III type cameras, do not wind film throughout the sequence), use fast shutter speed to get the solar image on the side or corner of the frame. *The camera should not move or shake throughout the sequence.* Exposure timing can be controlled with an external shutter (or a second camera body in front of the camera). A rectangular slot in a cardboard, moved rapidly across the camera lens is often suitable. The first exposure is taken just before "first contact". After that, take one exposure every 10 minutes, slowly increasing the exposure timing as you reach the crescent stages. At totality, remove the filter and give a large timing. (With Click III type cameras you may give quick repeated exposures with fixed shutter speed.) The last exposure is taken just after "fourth-contact".

2. *Direct camera with standard lens and solar image projection (no filter).* Here, a telescope projects the solar image on a white screen placed behind the eyepiece. Direct sunlight should be shielded from the viewing screen with the help of a cardboard mask or black cloth. The camera is now focussed from about 1.5 m away on this screen image and a normal photograph taken. The screen should be white, smooth and spotless. The partial stages, including sunspots, can be easily recorded. The method has a great advantage—large image sizes can be photographed even with small focal length lenses. But at totality, the image is often too faint.

3. *Single-lens reflex camera with telephoto lens and filters.* Use lenses of 300 m to 1,000 mm focal length on a firm tripod. Now take single frame shots of each phase and repeat the procedure throughout the sequence. At totality take several pictures with varying aperture-exposure combinations. Do not have a very enlarged disc image on the film—leave room for the corona which may extend several solar diameters on either side.

4. *Camera with telescope.* Out of the many configurations possible here, one would be to adjust the telescope focus to give parallel light emerging from the eyepiece and then fix the camera (also focussed for parallel light) coaxially just behind the eyepiece. The mounting should be rock steady.

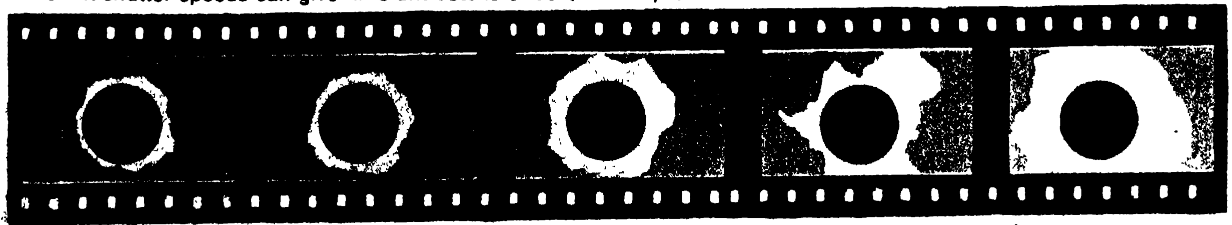
Another method is to project the image formed by the telescope eyepiece directly on to the film in the camera body. The camera lens is not used here.

Rehearse in advance and maintain a written record of all you think you must do. And while photographing, try to include a landmark or silhouette in the picture together with the eclipsed sun. Perhaps you may be lucky to get bright stars in the background, or maybe an unexpected comet! In any case, good luck to you, and in your excitement don't forget to remove the lens cap before you click.

J.B. MISTRY

Prof. Mistry, who is a founder-member of the Amateur Astronomers' Association, Bombay, teaches physics at St. Xavier's College, Bombay.

Different shutter speeds can give different details of corona and prominences



The eclipse families

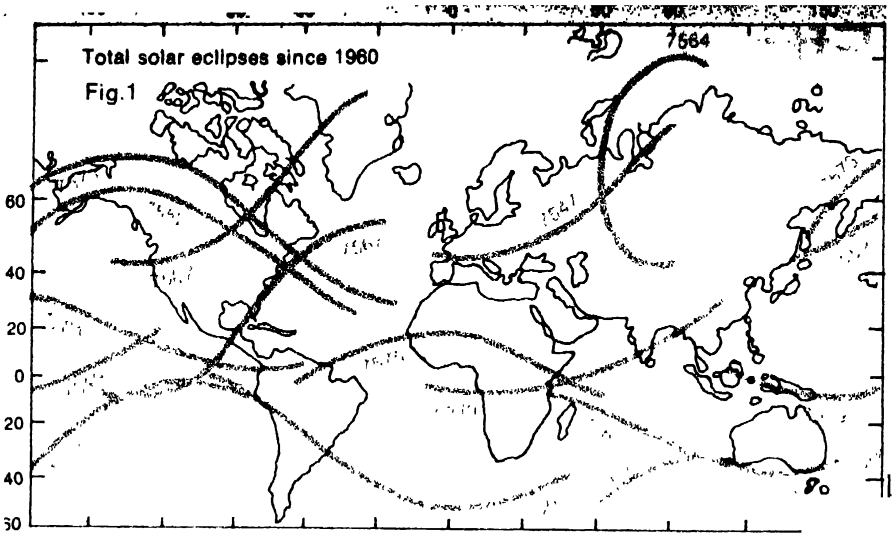
THERE is a kind of periodic cycle of occurrences of eclipses. It is called saros (from the Greek *saros*, meaning recurrence). Almost every eclipse, whether it is solar or lunar, partial or total, repeats itself at a regular fixed interval without undergoing much changes in its nature and characteristics.

Although known probably since the Babylonian times (1000-500 BC), it was Edmund Halley in the early eighteenth century who christened this cycle and also gave it a theoretical foundation One complete saros cycle is equivalent to 6585.3212 days, or 18 calendar years and 10 days when there are five leap years (11 days in case of 4 leap years) and 7.709 hours. Eclipses connected by successive saros cycles constitute what is called a saros family All eclipses that occur within an interval of nearly 18 years definitely belong to separate saros families Fig. 1 shows the paths of totality of all the total solar eclipses that occurred in the past 20 years Each of them belongs to a distinct saros family and is likely to be repeated for centuries ahead. The eclipses of 16 February 1980 and 4-5 February 1962 are the members of the saros family number 130.

Such a recurrence of an eclipse, however, must imply that the sun and the moon return to their exact previous relative states of motion (see sky map on p 46). In fact, a saros cycle guarantees (a) their return to the 'exactly' same relative phase in longitude (the moon orbits the sun exactly 223 times in 6585 3212 days, (b) the moon's return to 'approximately' the same phase in latitude (actually the moon crosses the sun's path from south to north, through the socalled ascending node, exactly 242 times in 6585.3572 days), and (c) the moon's return to 'approximately' the same apparent angular size (actually the moon regains its same apparent angular size for exactly 239 times in 6585.5375 days).

Now, apart from the condition (a) which merely predicts a full moon or a new moon, it is the condition (b) which guarantees recurrence of an eclipse; the condition (c) ensures no change in the nature of a solar eclipse, that is whether it is total or annular.

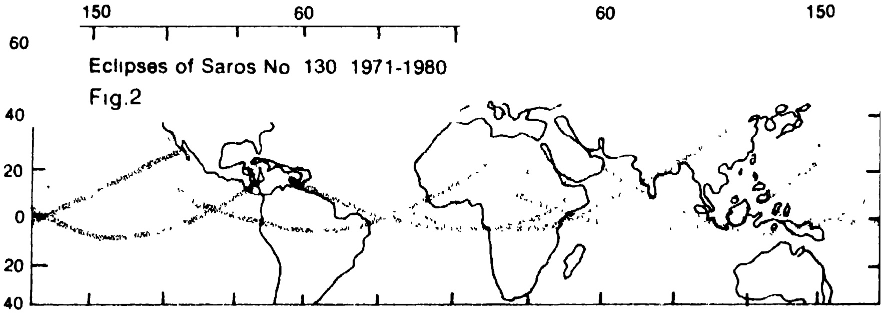
Although the degree of coincidence of all these three periods is remarkable, there is bound to be a very small but gradual mutual drift as a particular family of saros cycles grows older. Consequently, the essential condition of recurrence of eclipse will gradually fail to synchronise till a critical limit of drifting apart is reached beyond which the eclipses will cease to recur. So every saros family has a beginning and an end. In fact, it lasts only for 70 to 80 cycles, spanning more than 1,300 years.



Total solar eclipses since 1960

Fig.1

7547	1961	Feb 15	7549	1962	Feb 4-5	7552	1963	Jul 20	7587	1979	Feb 26
7557	1965	May 30	7560	1966	Nov 12	7564	1968	Sep 22	7589	1980	Feb 16
7567	1970	May 7	7573	1972	Jul 10	7575	1973	Jun 30			
7577	1974	Jun 20	7582	1976	Oct 23	7584	1977	Oct 12			



Eclipses of Saros No 130 1971-1980

Fig.2

Dec 18,1871 Jan 14,1926

Dec 22,1889 Jan 25,1944

Jan 3-4,1908 Feb 4-5,1962

7 Feb 16,1980

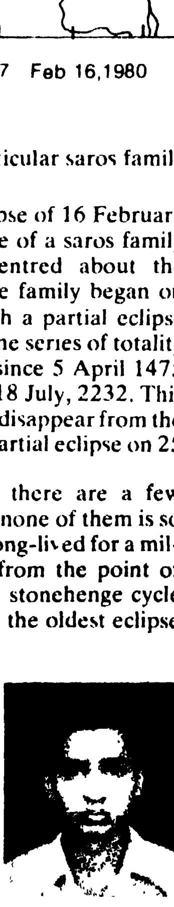
Saros families have four more characteristics. Firstly, every saros family is centred about a particular node either ascending (from south to the north of the sun's path) or descending (down to south from the north of the sun's path). Secondly, if it is about the ascending node, the moon drifts south during successive cycle and, as a result, the related saros family begins around the terrestrial north pole and advances steadily southwards until it disappears at the other pole. (Of course, it reappears as a new saros family after about 6,000 years with the polarity reversed. In fact, every new moon and full moon which now fails to produce an eclipse simply belongs to the dead phase of some saros family.) The sequence is just reversed if the related saros family is centred about the other node. Thirdly, every saros family evolves from the partial to the central phase and finally ends with a period of partial phase. And lastly, the exact period of a saros cycle contains a fraction of a day which is very nearly one-third of a day.

So the beginning point of an eclipse (especially the path of totality of a solar eclipse) on the surface of the earth dirfts towards the west by about 115° during successive saros cycles. And every fourth cycle of any family nearly brings it back to its original position. Fig.2 indicates this pattern for a particular saros family (No.130).

The total solar eclipse of 16 February 1980 is the 50th cycle of a saros family (No. 130),. It is centred about the descending node. The family began on 20 August 1096, with a partial eclipse around Antarctica. The series of totality has been continuing since 5 April 1475 and will continue till 18 July, 2232. This family will eventually disappear from the Arctic region with a partial eclipse on 25 October, 2394.

Apart from saros, there are a few more such cycles, but none of them is so short-cycled and yet long-lived for a millennium. Of course, from the point of view of antiquity, the stonehenge cycle of 56 years is perhaps the oldest eclipse cycle known so far.

N. C. RANA



Mr. Rana, 26, did his master's degree in physics from the University of Calcutta. At present he is a research associate with the Radio Astronomy Group, Tata Institute of Fundamental Research, Bombay. His work is primarily related to astrophysics.

Effects on the earth's atmosphere

A. P. Mitra

The eclipse produces different effects at different heights

THE EARTH'S atmosphere extends to many thousands of kilometres in space. The ionosphere, so called because it is the ionised region of the atmosphere, extends from about altitude 60 km outwards (Fig.1). Although inferred much earlier, the first conclusive proof that the ionosphere exists was made only in 1924, when direct reflection of radio waves was observed.

The regions below 60 km is usually referred to as the "non-ionised" atmosphere. But, right down to the ground level, the "non-ionised" atmosphere has a sizeable number of positive and negative ions with concentrations sometimes as large as 1,000 per cu cm (Fig.2). Furthermore, during solar disturbances, electrons are generated in fairly large numbers here. Thus, today, the ionosphere and the lower atmosphere are no longer considered separately. Appropriately, the entire atmosphere (which is subject to the earth's magnetic field) could be considered as a massive mixture of electrons, ions and neutral particles in proportions which are different at different altitudes.

These neutral particles are not merely molecular nitrogen and oxygen, but include also a number of trace species, some of which are produced in the atmosphere as a result of complex chemical reactions. Important among them in atmospheric chemistry are nitric oxide, ozone, water vapour, atomic oxygen and the hydroxyl (OH) radical, although their presence can in some cases be as low as a few parts in a trillion. The electrons, ions and many of these trace species result from the interaction of the atmosphere with solar radiation.

Studies of solar eclipse effects on the earth's atmosphere are aimed primarily at understanding how the various radiations change as the sun is gradually obscured. The wavelengths involved are different in different cases; mainly, those in the ultraviolet (UV) and x-ray regions are absorbed in the atmosphere. Besides, eclipse studies also consider the chemistry of the ionosphere as the radiation is changing. More recently, studies are also being done on some of the minor constituents of the relatively low part of the atmosphere, known as the stratosphere, where ozone concentration is the maximum.

Early work

The earliest solar eclipse study on record (17 April 1912) measured effects on wireless telegraph signals. Similar studies were carried out again during several other eclipses till 1930, all of which measured radiowave signal strengths at various frequencies. And, although the long wavelengths provided interesting knowledge, qualitative results were few except for some indication that cutting off of solar radiation does alter the signal strength.

The discovery of the ionosphere by E.W. Appleton and others in 1924 and the installation of vertical incidence ionospheric recorders at various locations started a new phase of study. The first measurements of changes in ionospheric layers were conducted during the eclipse of 31 August 1932. The next year, a Calcutta group reported the first Indian work. After that, for some 30 years, changes in ionospheric layers—the heights and associated properties—were recorded for a number of solar eclipses in different parts of the world using essentially the same equipment: a combination of ionosondes (a specially designed radar device) and receivers that took up radio signals reflected off the affected part of the ionosphere. The principal interest then was to monitor the manner in which different layers of the ionosphere react as the solar radiation is obscured and also to understand the nature of the solar radiation responsible for producing the different ionospheric layers. It was clear that an eclipse had always a marked effect on the lower part of the ionosphere, the D and E layers, and some of the changes could be associated with known active areas on the sun's disc. However, if one examined more carefully the ionisation changes during totality, it looked as if 10 to 15 per cent of the ionising radiation remained even when the sun's visible disc was completely covered. What we call the "eclipse function" (the ratio of the instantaneous solar flux at a given wavelength to its uneclipsed value) did not vary as expected. The expectation is that it should be unity at the first and the fourth contact, and zero at the second and the third contact for a total eclipse. What actually happened was quite different. Apart from

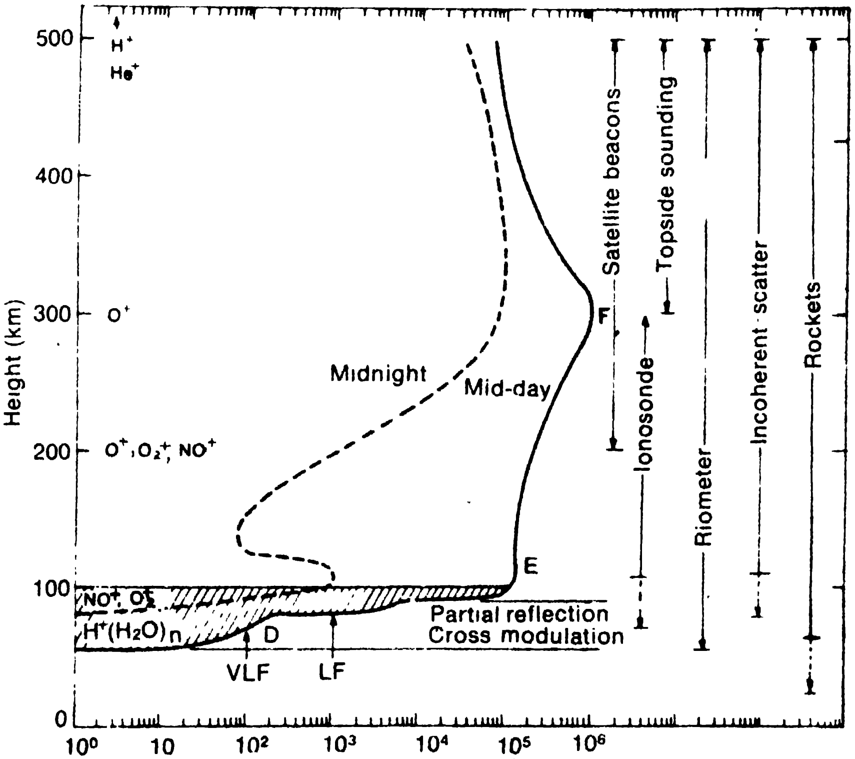


Fig.1: The earth's ionosphere, consisting of electrons and ions, extends over a major part of the near-space environment; the electrons exist from about 60 km to many thousands of kilometres. Much of this very extensive region is subject to varying degrees of changes during a solar eclipse, although in the F-region and the topside ionosphere the effects become progressively more and more complex and the lifetime of electrons becomes larger than the eclipse duration. Other important experimental tools are also indicated above

the fact that the radiation responsible for ionospheric layers was not entirely cut off at totality, there were irregular variations in ionisation and, as was later confirmed, in the radiation curve. This indicated two things: First, that the ionising radiation was not coming uniformly from the solar disc and that there were certain regions where these radiations were concentrated. Second, part of the radiation was coming from outside the solar disc and was, therefore, not eclipsed when the disc was covered.

Rocket campaigns

The third phase of eclipse observations came in the late 1960s and early 70s when large rocket campaigns were undertaken at suitable locations on the eclipse path. Rockets were fired at frequent intervals during the eclipse including at least one during totality. Three main campaigns were those of 20 May 1966 (Greece); 12 November 1966 (Brazil); and 7 March 1970 (Wallops Island, USA).

There were, in addition, a few other eclipses on which some stray measurements were taken, like the one on 30 June 1973. Yet, by and large, most of our understanding of the changes in the ionosphere came from the above three rocket and satellite campaigns. The results of these three campaigns gave a consistent picture of what happened in the earth's lower ionosphere during a solar eclipse. The first obvious result was that the electron density decreased at all heights, it being quite different even between levels as close as 70 and 90 km. At 90 km, the decrease was by a factor as large as 100.) Second, positive ion concentrations at the lower heights did not decrease so much. Here the factor was only around 10. Also, water cluster ions, which are normally observed up to 80 km, now extended to about 90 km. At 70 km, it looked like a near collapse of ionisation within a few minutes of totality.

It seemed that, in order to explain this drastic decrease in electron concentration, one had to increase the loss coefficient (by the factor of 100) to a value around 10 $^{-4}$cm^3/sec. It was difficult to think of any mechanism that would give such a large loss coefficient at these heights. The appearance of water cluster ions up to 90 km was, however, an easier thing to understand. This was typical of the twilight situation brought about by the eclipse.

There were also very interesting glimpses of the active regions of the sun contributing to atmospheric ionisation. Pictures of the sun were taken in ultraviolet- and x-rays during the solar eclipse of March 1970 with a rocket. These were compared with "active" regions inferred primarily from changes observed in the ionosphere.

Unfortunately, rocket measurements were limited to the lower heights of the ionosphere. For the upper regions, one had still to depend on measurements made from the ground, particularly with the ionospheric recorder. But, a new technique was soon added: the reception of satellite radio beacon signals in the VHF (very high frequency) region from geostationary satellites. Since radio waves have to pass through the entire ionosphere, the effect observed is an integrated one. Much of the effect, however, actually comes from regions around 300 km and, consequently, the changes that one sees are relevant for that height regime. The electron density was found to decrease at these heights also (Fig.x) Apart from the nature of decrease, there is one important difference between changes in the upper ionospheric levels and those below 100 km. The minimum electron density is delayed after totality by an amount which increases with altitude. The delay is only a few minutes at 80 km

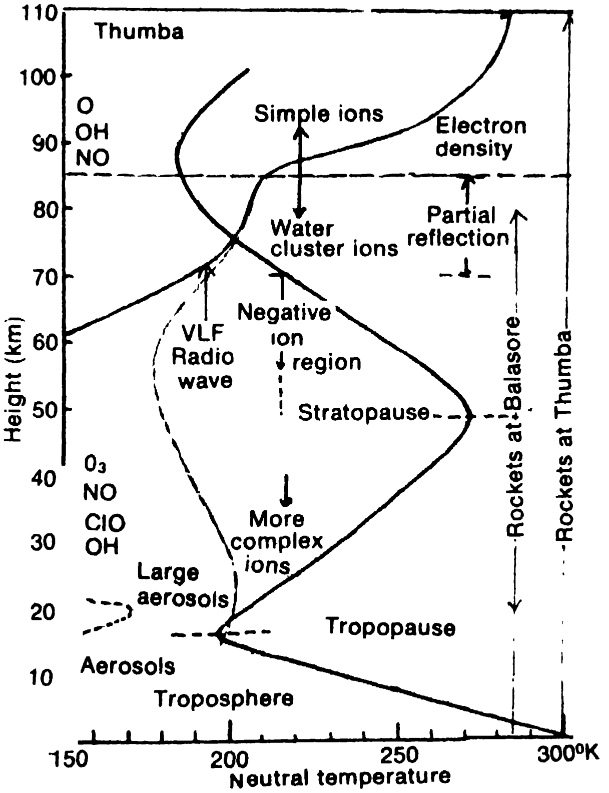


Fig.2: A major effort will be directed towards the region below 100 km, representing the mesosphere, stratosphere and the troposphere. Three rockets to be fired from Thumba will study the ionisation of the D-region between 60 to 100 km, and two rockets to be flown from Balasore will study the positive ions in the region below 60 km. This region now forms part of a very extensive international scientific activity under the Middle Atmosphere Programme (MAP) in which India is taking part. Different parts of this region behave quite differently in terms of atmospheric chemistry and in their response to solar eclipses These are also regions where minor constituents left of diagram often play a dominant role

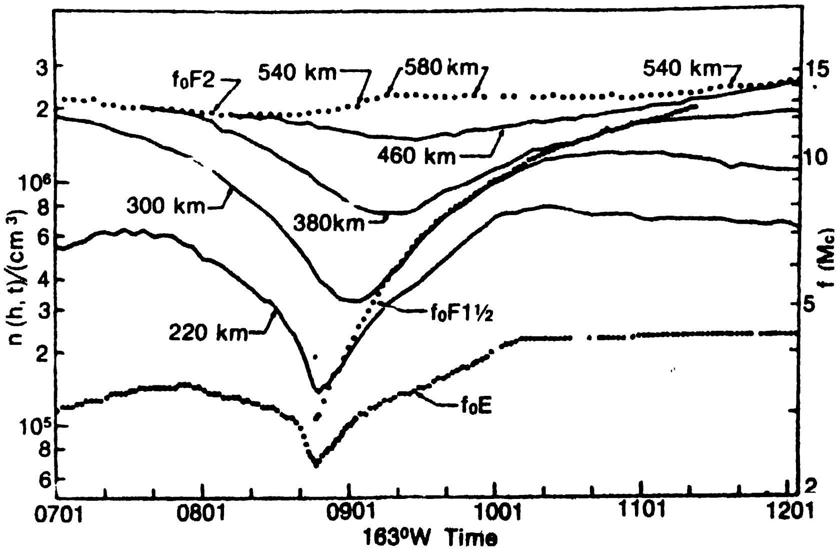


Fig.3: This figure gives typical behaviour at the ionospheric layers: electron density decreases at all heights during a solar eclipse but the percentage change becomes progressively smaller as one goes to higher levels and the maximum effect also gets more and more delayed

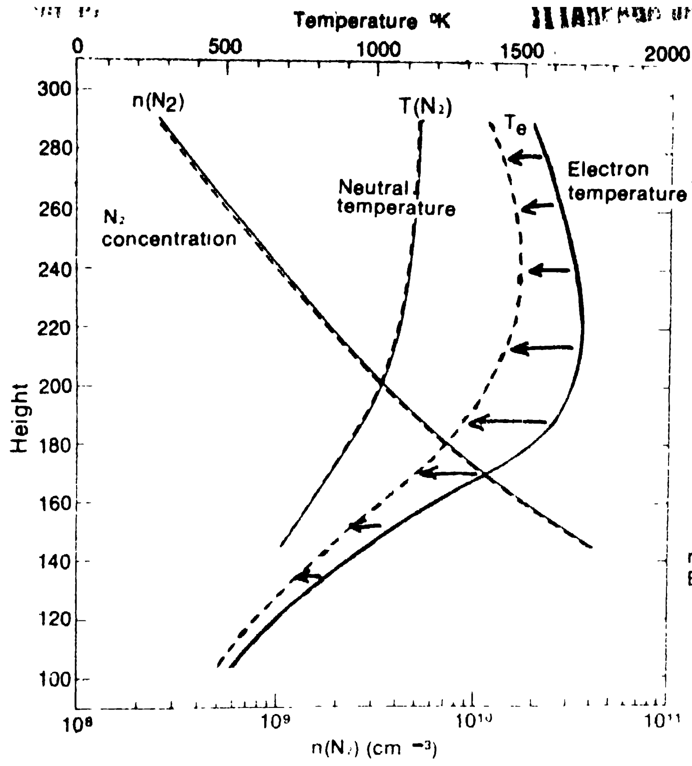


Fig.4: Rocket measurements of densities (n) of the neutral high atmosphere from Wallops Island, USA during the 1970 eclipse by US scientists. The solid curves represent observations when around 300 km the solar obscuration is 45 per cent; the dotted curves give the conditions at 84 per cent obscuration No change was observed for N_2 and for atmospheric neutral temperature But a large decrease in electron temperature was noted

but a couple of hours at 300 km. This is a picture that is relatively easy to understand in terms of electron loss coefficient since we know that the electrons take much more time to recombine at the higher than at the lower heights.

This introduces some additional problems. At these great heights, where electrons have relatively long lifetimes comparable to or even larger than the eclipse duration, other effects can be dominant, such as motions in the ionosphere of both ionised and neutral particles. Further, it is not the electrons only that change in this part of the atmosphere; there is also a decrease in the electron temperature. Such a change was detected during the 1970 eclipse from the US range at Wallops Island with two rockets flown with identical payloads (Fig.4). On the other hand, no perceptible change occurred in the concentration of molecular nitrogen of the neutral atmosphere. At lower heights also, no perceptible change in atmospheric neutral density or neutral temperature occurred; for example, in a series of five probes flown with rockets at Wallops Island to sound neutral particle pressure, temperature and density over 30 to 125 km, no change was observed that could be attributed solely to the solar eclipse.

One interesting experiment in which Dr. B.C.N. Rao of the National Physical Laboratory (NPL), New Delhi, participated concerned photoelectrons. These are low-energy electrons generated in the ionosphere and are part of the heat source available to the upper atmosphere. A special feature is that these photoelectrons can travel from the location of its origin in one hemisphere to another by proceeding along the magnetic field lines. It is not easy to determine how much of the photoelectrons that one measures has been produced locally and how much has come from the conjugate ionosphere. In an exciting experiment carried out by Meier and Rao during the 1970 eclipse, the arrival of conjugate photoelectrons was identified and their values measured.

There is another interesting effect. In a solar eclipse, the moon shields a limited region of the earth's atmosphere from the heating effect of the solar radiation. This shadow travels through the earth's lower atmosphere with supersonic velocity. The velocity varies from 1600 kmph as it passes the equator to 3,020 kmph at the highest latitude. This causes neutral gas to emit internal gravity waves that form a bow-wave about the shadow region. Attempts have been made to look for such internal gravity waves during eclipses. Such a wave was *apparently* detected with satellite radio beacon observations for the 1970 eclipse and is shown in Fig.x.

The reality of these gravity waves, however, is still a matter of dispute. The theory by G. Chimonas and C.O. Hines in 1970 suggested that the magnitude of the pressure perturbation would be as much as 10 per cent at an amplitude of 10 km. Measurements with beacon satellites gave fluctuations of the order of 1.5 per cent. Later works failed to see fluctuations of total electron content.

Current phase

We have now entered what I would call the fourth phase of investigations. Some of the interests have now changed. Satellites are no longer used only to measure changes in solar radiation, but also changes in the concentration of trace species. Many of these trace constituents are now being monitored by satellites. For example, the satellite Nimbus-7, launched in October 1978, has monitored and will continue to monitor carbon dioxide, water vapour and nitric oxide, besides the temperature, in the earth's stratosphere and mesosphere.

It is important to measure these changes. Atmospheric ozone reaches its maximum concentration in the stratosphere and, of late, the problem of ozone depletion has attracted much attention. But ozone changes are only a part of a total system of chemical changes that occur in the stratosphere and the troposphere. These changes involve many minor constituents, the principal ones being the oxides of hydrogen, nitrogen and chlorine. If these changes do indeed occur (unambiguous changes have been observed only with Nimbus-4 for the solar flare event of August 1972), there are several consequences. One

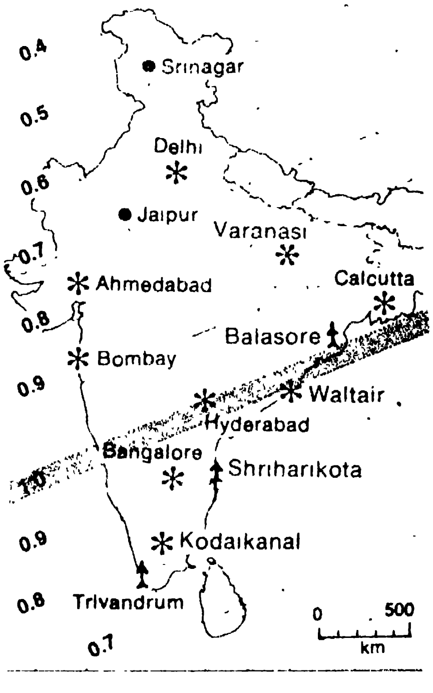


Fig 5 Major locations participating in the solar eclipse campaign are shown These include the three rocket ranges Trivandrum (Thumba), Shriharikota (SHAR) and Balasore; the satellite radio beacon networks at Delhi, Hyderabad, Bangalore, Ahmedabad and Calcutta, the meteor radar wind observations planned at Waltair, and the vertical incidence ionosondes at a number of places

is the increase in the ultraviolet radiation around 3,000 A^{o} with a consequent increase in skin cancer hazards. But another, perhaps more important, effect concerns possible changes in climate.

The third area of study concerns the atmospheric global electrical circuit. There is a growing belief that the lower weather-forming levels of the atmosphere are coupled to the upper levels. Among the several processes, one major coupling process occurs through an atmospheric global electrical circuit generated through thunderstorms and connected through the D region and stratospheric ions. Ions in the stratosphere can, therefore, be very important. Strangely enough, not many measurements are available even under normal conditions for this part of the atmosphere. It would be interesting, therefore, to see how the concentrations of stratospheric ions change during solar eclipses.

The 1980 eclipse

The Indian preparations for the February 1980 solar eclipse, as far as the atmosphere is concerned, depend primarily on three rocket campaigns, some measurements from satellites and a few ground experiments. Three rocket campaigns will be undertaken from Thumba (where the solar obscuration will reach about 80 per cent) in Kerala, Sriharikota (obscuration 90 per cent) in Andhra Pradesh, and hopefully from a newly established small rocket range at Balasore, Orissa (where obscuration will be nearly total). At Thumba five RH-300 rockets will be launched; three of these are for an extensive study of the D region of the ionosphere, one for measuring the electrojet current (a thin electric current layer in the ionosphere) and one (if the weather is favourable) for measuring gravity waves believed to be generated by solar eclipses. The main objective of the D region experiment in which scientists of both the NPL, New Delhi, and the Physical Research Laboratory, Ahmedabad, are participating is to understand the very large loss rate that was observed in the earlier rocket campaigns.

The current thinking is that such a large loss coefficient can be caused by the insolvement of aerosols. Not much is known about aerosols in the lower ionosphere, but, in an experiment conducted jointly with Japanese scientists in March 1976 with a rocket launched from Thumba just after sunrise, we did get some indirect evidence of aerosols around 70 km. A crucial parameter to measure is the rate of change of electron density as the eclipse progresses. One must, therefore, measure the electron concentrations at least at two close points during the eclipse. The plan is, therefore, to launch the first D region rocket after the onset of the eclipse at about 50 per cent obscuration before the maximum. The second rocket will be launched some 20 minutes later at 75 per cent obscuration just a few minutes before maximum obscuration. The third D region rocket will be launched on the next day (17 February 1980) for comparison. The equipment carried by the rockets will allow measurements of both electrons and positive ions and also of ozone. Unfortunately, because of the range logistics, a shorter interval between rocket flights is not possible nor will the obscuration be total at this range.

It is also important, if we are to convert these measurements to an understanding of the chemistry of changes in the D region, that we should measure the concentration of the critical trace constituent like nitric oxide at these heights. A joint experiment between the NPL and Japan was conducted several years ago from this rocket range to measure nitric oxide concentrations. We have some ideas as to how it varies, but it needs to be measured at the time of the eclipse. Since this measurement must be done at twilight, we have planned to fire the fourth rocket with a Japanese nitric oxide payload on 17 February (the day following the eclipse) morning.

Experiments conducted from Sriharikota will primarily explore the higher, F region of the ionosphere. For this, two 560 RH-1 rockets will be launched just after the first contact and the second during the maximum phase of the eclipse. These rockets are expected to carry the payloads to heights of about 300 km and will measure the changes in electron density and temperature. In this, there is a plan also to incorporate electron temperature probes from Japan. Finally, the first stratospheric measurements during solar eclipse from India are planned to be carried out from the Balasore range. If these experiments are indeed carried out (there are some difficulties in this regard), the primary objective would then be to measure the changes in densities of positive ions in the stratosphere.

An equipment has already been installed by the NPL, New Delhi, to measure changes in the total electron content of the ionosphere by using radio beacons from a Japanese satellite. There are other units located at Hyderabad and Bangalore. Similar measurements will also be made during the eclipse by the Physical Research Laboratory, Ahmedabad, and by scientists at the Universities of Calcutta and Andhra. If the eclipse does indeed produce gravity waves, we should be able to establish evidence for it through indigenous efforts with our wide network of stations.

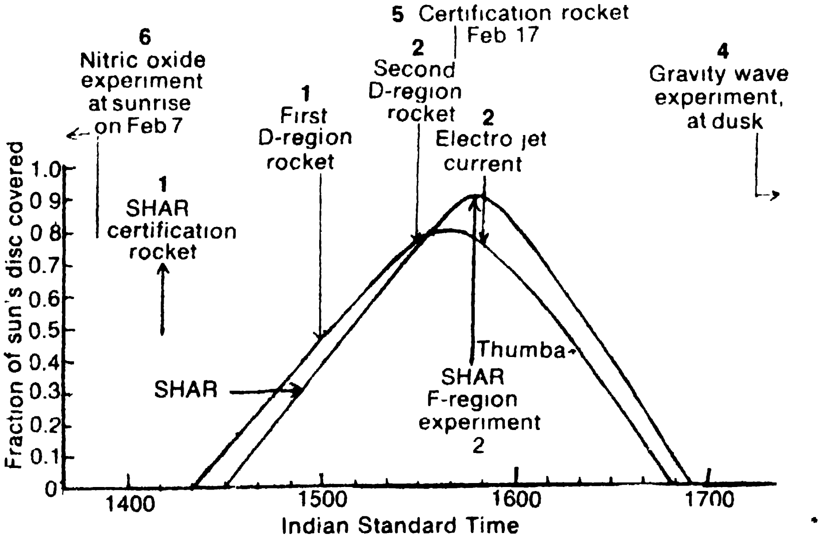
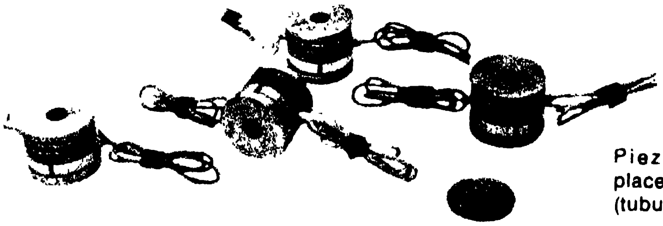


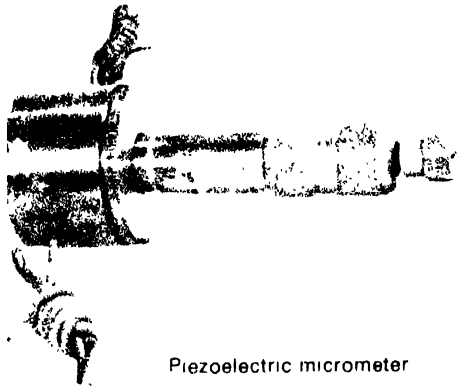
Fig.6· Scheduled link of rocket flights for the ranges of Thumba and SHAR. Because of range logistics, it is necessary to give about 20 mins between two rockets flights. Two Russian M-100 rockets will also be flown from Thumba on the day of the eclipse carrying meteorological sensors

Dr Mitra is Scientist at the National Physical Laboratory, New Delhi. A Shanti Swarup Bhatnagar Prize winnder in 1968, his pioneering work on employing cosmic radio noise for studies of the upper atmosphere resulted in a series of discoveries in solar physics and cosmic rays. He has carried out studies on the ionospheric effects of solar flares and has established one of the most extensive radio flare systems at the NPL. He developed an atmospheric model from observations of satellite drag and iniated new D-region rocket experiments.

Piezoelectric devices for precision movement



Piezoelectric displacement transducer (tubular type)



Piezoelectric micrometer

THERE has always been a great need of suitable devices for accurately giving minute displacements in a large number of optical alignment problems such as in laser interferometry, Fabry-Perot spectrum analyser, holography and coherent optical data processing. Devices for giving such small displacement of the order of wavelengths of light, or even a fraction of it, by mechanical means require high precision gears, which are enormously expensive. Certain piezoelectric devices have been developed by the authors at the National Physical Laboratory (NPL), New Delhi, for this purpose. They are: (1) piezoelectric displacement transducer, (2) piezoelectric tubular displacement transducer and (3) piezoelectric micrometer.

The devices are rigid, compact, economical and are remote-controlled. These can be used in a wide variety of optical, mechanical and electro-optical systems, both in industrial and research applications, such as stabilisation of amplitude and frequency in continuous wave lasers, scanning of Fabry-Perot interferometer and spectrum analyser. These may also be freely used as adjustment mechanisms, in a precision mirror mount and in several angular orientation devices. In these devices, lead zirconate titanate ceramic material developed at the NPL has been used.

The working principle of these piezoelectric devices is that if an external DC field is applied to a polarised piezoelectric ceramic disc along the direction of polarisation, a contraction or elongation in the thickness of the ceramic disc is observed, depending on the direction of the applied field. This effect is attributed to the alignment of the domains in the direction of electric field. Such piezoelectric devices have an inherent non-linearity and a 'hysteresis' effect in displacement versus voltage-characteristics. The effect is negligible for small voltage (100 V), but increases for higher voltages. The cumulative effect of a number of such discs can be added up, if these ceramic discs are stacked suitably one over the other and an electric field is applied.

The piezoelectric displacement transducer consists of a number of polarised lead zirconate titanate ceramic discs which are suitably cemented together one over the other to form a stack and has terminals for applying a DC voltage. Its ends are carefully lapped for better parallelism and it is encapsulated in suitable casing with proper insulation. This displacement transducer can provide movement with a resolution ranging from approximately 0.025 micron per 10 volts to as large as 25 microns for 3 kV. Its performance is not noticeably affected by varying loads even up to 15 kg.

The piezoelectric tubular displacement transducer is a special type of piezoelectric displacement transducer having an axial hole through its length. It works on the same principle as the piezoelectric displacement transducer. It is specially useful for frequency tuning and modulation of laser and can also be used in the Fabry-Perot spectrum analyser for moving axially one of the Fabry-Perot mirrors, by applying a ramp voltage waveform.

The piezoelectric micrometer consists of a tubular stack of ceramic rings which is suitably coupled with a micrometer head having a least count of 0.01 mm. Its other face is fixed to the transducer casing with an epoxy under pressure. Threads are provided on the micrometer for rigid clamping to the object to be displaced. As the stack of ceramic rings expands or contracts, depending upon the polarity of the applied voltage the spindle of the micrometer head moves backward or forward, causing a proportionate displacement of the object in contact with the spindle tip. It is an excellent device which can provide a continuous movement from 0.025 micron to 10 mm.

Two patents on these devices have been taken. These devices have been successfully used by a number of scientific organisations and universities.

The technical knowhow for the manufacture of these devices can be obtained through the National Research Development Corporation of India, New Delhi. These piezoelectric devices can be now obtained from the NPL on payment

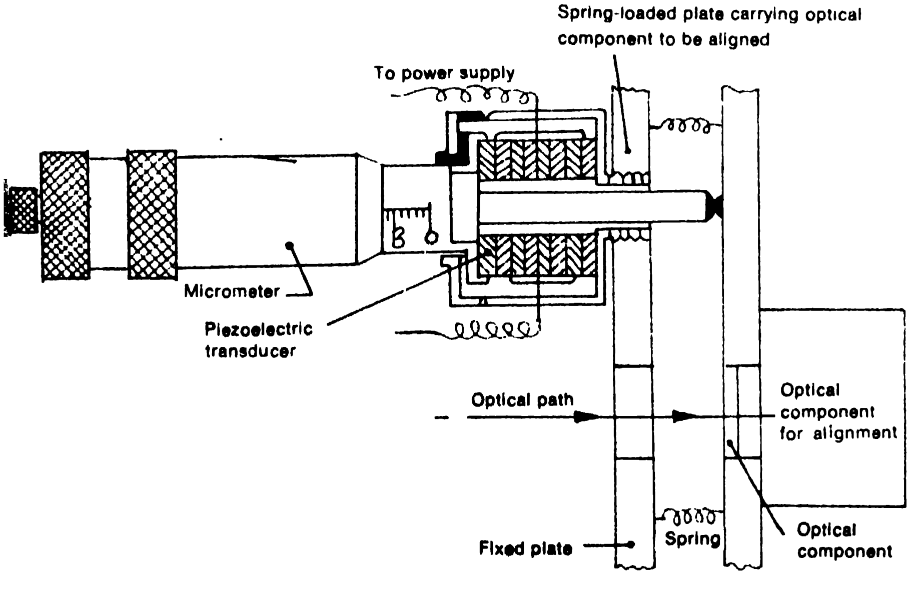


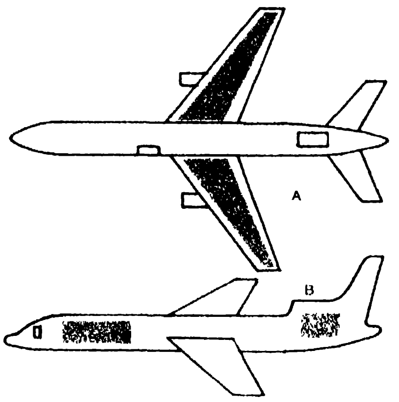
Fig 1. Constructional details of piezoelectric micrometer and its application in optical alignment

V.N. BINDAL

MAHÉSH CHANDRA

The authors are with the Ultrasonics and Electroceramic Section of the National Physical Laboratory, New Delhi

Liquid hydrogen for aircraft



Conventional aircraft carry fuel in tanks within their wings (A). The liquid hydrogen-powered planes would have cryogenic tanks within the fuselage (B)

ESTIMATING the world oil reserves, according to an oil expert, is like guessing the number of beans in a jar buried deep under the earth. Proven oil reserve estimates, based on the best available evidence, are expected to last 30 years at the current consumption rates. Such dwindling oil supplies have affected adversely many heavy users of energy like the airlines, who feel the pinch of rising jet-fuel prices acutely.

To economise on fuel, new aircraft are being designed with increasingly efficient engines. Compared to the revolutionary jets of the late 1950s and the awesome jumbos of the early 1970s, the aircraft of the 1980s will not only be more automated and efficient to operate but also be far less fuel-thirsty. Such fuel-gulping monsters as the Anglo-French supersonic Concorde will be left unsold and unwanted.

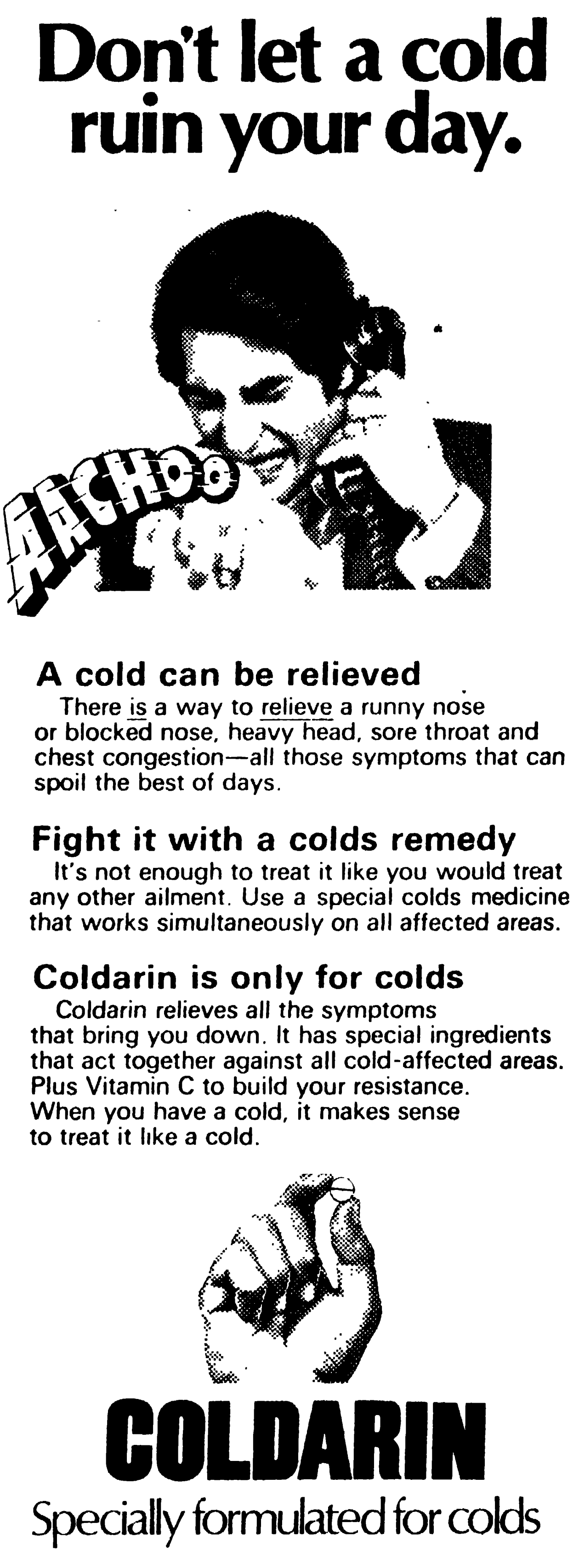
All the same, jet transports of today, as well as their currently envisaged successors, are committed to using petroleum-based fuels as a source of power. And most aircraft based on present generation technology will be around even after world crudeoil production passes the peak. Hence, unless new oil sources are developed well before supplies decline, airline systems will be widely dislocated.

The choice of an alternative fuel source is between jet-fuel derived from synthetic crude (synjet) or a wholly new type of fuel. While studies on extraction of synthetic jet-fuel from coal and other natural hydrocarbons are already under way, Lockheed Aircraft Corporation of USA advocates a switchover to a not-so-new type of fuel—liquid hydrogen. The main advantage of liquid hydrogen is that its energy content per unit weight is nearly three times greater than that of the hydrocarbon fuels. Moreover, hydrogen burns cleanly and consistently, causing less air pollution than the cleanest of modern petroleum-burning engines. Modern jet engines can work on hydrogen fuel.

Hydrogen, however, is highly combustible, and is believed to be quite unsafe for routine use. Though the accident-prone history of hydrogen-filled airships of the 1920s and 1930s strengthens this belief, ever since the beginning of space probes, hydrogen has been handled safely and without incidents. Moreover, the nature of hazards in the case of aviation fuels is different from other forms of transport hazards. For example, the number of passengers escaping in a "survivable" accident depends on the speed with which fire spreads after fuel tanks have ruptured. When hydrogen is ignited, because it is so much lighter than air, the fire soars upwards, instead of expanding sideways as in other liquid fuel fires. Thus, the aircraft would not be sitting in a pool of flame. And because hydrogen boils at a very low temperature, the fuel would vaporise and dissipate quickly. Burning hydrogen also radiates only one-tenth as much heat as aviation kerosene and hence is likely to cause burns over a smaller lethal radius.

In order to provide a "proof of concept" as well as handling and flying experience, Lockheed has made a proposal (*Intervia* 9 1979) for building an experimental airline, a hydrogen-fuel cargo aircraft, derived from the existing designs. This proposal advocates the use of a fleet operated from four specified airports around the world, most suitably situated to set up hydrogen production facilities nearby.

JAY RAJA
Jay Raja is with the Systems Reliability Group, Vikram Sarabhai Space Centre, Trivandrum.



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Far from authoritative

Biochemistry, Volumes 1, 2 and 3 by S K Dasgupta, Macmillan, New Delhi, 1977, 1031 pp, Rs 25 75, Rs 17 25 and Rs 16 00 respectively

PROF S K DASGUPTA, a teacher of biochemistry for the past several years, has attempted to bring in the essentials of biochemistry to serve, principally, as a text-book for medical students. The first volume, which deals with the chemical background of the study of life, includes the chemistry of important constituents like carbohydrates, lipids, proteins, vitamins and hormones. The second covers such aspects as organisation of the human body, biochemical functions of various organs, bioenergetics, digestion and absorption. The last volume incorporates topics on the metabolism of lipids, proteins, energy metabolism, respiration, evolution and ecology

Since the presentation is in simple and concise language, the beginner should have no difficulty in getting a grasp of the subject. What is, however, most disheartening is the author's obviou lack of effort to exercise precision in scientific narration and to give the latest information wherever possible. Some exciting discoveries of the last few years in biochemistry are not even mentioned

The book contains also several factual errors. For instance, the explanation that nucleolus is "the site of protein and RNA synthesis" (I 4) is wrong Again, the concentration of amino acids is expressed in millimicrons (I 96, Fig. 4.2)! The title of Fig 6 1 reads: "The Watson and Crick model of double helical structure of DNA (modified)." But what is modified in the DNA structure is nowhere mentioned.

These are only a few examples. Many more could be mentioned if space permitted.

It is hoped that the future editions will attempt to eliminate these and the many spelling mistakes, and also incorporate newer information. Otherwise they would remain far from being considered authoritative texts on the subject

D S PRADHAN
R C. TRIBHUWAN

The reviewers are with the Nucleic Acid Section, Bhabha Atomic Research Centre, Bombay

A welcome arrival

Introduction to Classical Mechanics by R.G Takwale and P S Puranik, Tata-McGraw Hill, New Delhi, 1979, ix + 425 pp, Rs 18

CLASSICAL mechanics is an important component of any physics course for both undergraduates and postgraduates. Even quantum mechanics which is the backbone of modern physics contains a number of classical concepts. Understanding these concepts must form an integral part of a student's training in physics, whether or not his physics degree is terminal.

So far, Indian students have had to use the well-known foreign texts—Goldstein, Landau-Lifshitz or Corben-Stehle—in the absence of any comparable Indian text. This is what makes the book under review a very welcome arrival.

Starting with two chapters on vectors which may be read with profit even by those who have done a course in vectors, the reader is taken to the main topics of mechanics. The book is so conceived that chapters 1-7, 9, a part of chapter 10 and chapter 14 could form an undergraduate course at, say, the present final B Sc level. Chapters 8 and 10-13 comprise the present first-year M Sc syllabus in Bombay University. However, it will not be out of place to suggest that the whole book could be used for a one-year course in mechanics at the B Sc level

Although the course material in the book is presented in a competent fashion, at times it appears to follow certain well-known texts too closely. A large number of questions and problems are given at the end of each chapter.

There are no serious conceptual mistakes anywhere, but there do appear a number of misprints (the long errata at the end has missed some of them). Important topics like symmetries and conservation laws find all too brief a treatment. One finds on p.231 the use of the word "double integral" to mean, presumably, the repeated integration of the second order differential equation of motion. In the chapter on relativity it would have been more appropriate, and in conformity with the present practice, to introduce the Minkowski metric instead of the outdated pseudo-Euclidean metric in the treatment of 4-vectors.

Judging from the competent treatment of the subject, good production and low price, the reviewer has no hesitation in recommending this book to every serious student of physics.

R.V. KAMAT

Prof. Kamat heads the physics department of St. Xavier's College, Bombay

Textile safety

Occupational Health and Safety in Textile Mills by V A. Shenai Sevak Publishers, Bombay, 1978, 79 pp, Rs 25

DEALING principally with occupational safety in textile industry, the book is intended for those with little background in chemistry.

The author outlines a wide variety of hazards that could arise from various chemicals used in the textile industry. He has also provided full flowsheets of textile processes and organisational patterns with the text.

Mill worker on the job — *trying conditions*

Although he has dealt with byssinosis at length, he does not touch upon the other hazards caused by cotton dust, like mill fever and acute respiratory illness arising from contaminated cotton. He also makes no mention of the weaver's cough, cross infection, skin afflictions, the potential health hazards of lifting and carrying heavy loads, the excessive temperature and humidity, poor ventilation and illumination.

The format is designed, for easy reference, in sub-paragraph form, with clearly defined headings. As such, it lends itself to easy reading and makes a good reference book on safety aspects. But it has very little on the health of textile workers. This slim volume will be of greater value to training and safety officers than to medical personnel.

HARWANT SINGH

Dr Singh is Deputy Director (Medical) at the Central Labour Institute, Bombay

Clues to the time factor

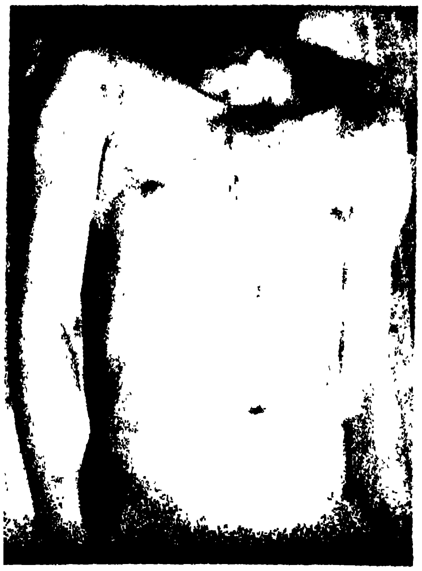
Pritam Phatnani

Time is a crucial factor in the analysis of any murder mystery. This brings us to the second of the W's — *When* did the victim die?

A MAN returned home from office around 8 p m on 16 October 1976 and found his middle-aged mother sitting dead on an easy chair. She had obviously been strangled with a coir rope and hit on the head with a heavy object. Some clothes, cash and a radio were found missing from the house.

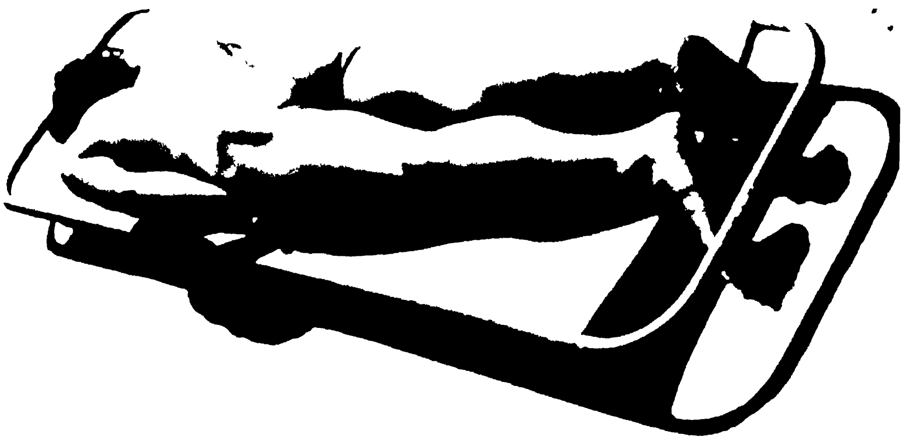
A preliminary examination showed that the woman had been dead for at least six to eight hours. And the next morning, during the postmortem examination, we could confirm that she had died somewhere in the afternoon between 2 p m and 5 p m, and most probably around 4 p m. Armed with this bit of information, the police continued their investigation and arrested a male suspect.

Although the suspect admitted having visited the lady on the day of her death, he insisted his visit was in the morning, at 11, and that he left the place at noon. Even the watchman there supported his story. This baffled the police who, by now, had strong evidences against the suspect. So, once again the time element was checked. But the result was the same: the lady *had* died during the later part of the afternoon.



Postmortem lividity on the front of a man's body

This suggested two possibilities: either the suspect was lying or he was altogether innocent. He was further interrogated, and the watchman warned of grave consequences in case he was abetting the criminal. The truth then emerged. The suspect, a known acquaintance of the lady, had killed her around 4 p m after she refused him a loan. The killer then left the premises around 5 p m with a cloth bundle in which he had hidden the radio.



Rigor mortis can result in a board-like rigidity. The picture was taken 12 to 18 hours after the man died

How do forensic experts determine the time of a death with such accuracy? Dead men tell their stories in a number of ways, mostly in the form of series of postmortem changes in the body. The changes give a clock work which when analysed gives reliable information regarding the time that elapsed between the death and the postmortem examination.

Let us touch upon them one by one. Many of these methods are used in combination. They not only help estimate the time since death, but also in breaking or confirming the alibi of the accused and in tracing what must have taken place during the dead person's last moments. At times they may also suggest the cause of death and mode of dying.

Postmortem changes

After the vital organs stop functioning, rapid heat losses occur till the body attains the temperature of the surrounding. The state of health, environmental conditions at the scene of death, and the type of clothing worn play important roles in the cooling of the body. Also, the body cools more slowly in the case of fat persons.

Although—on account of the above factors—the rate of cooling varies in each case, it is roughly 1.4°C per hour for the first few hours, slowing down gradually to the room temperature. For all temperature measurements, forensic pathologists rely most on the rectal temperature.

The stoppage of blood circulation after death results in a condition known as postmortem lividity. Due to gravity, blood collects at the underlying parts—the back of the body, for instance, if it were lying face upwards. Postmortem lividity commences within about half an hour and becomes marked after about six hours. About 12 hours after death, the blood coagulates and thereafter its position becomes fixed. This also gives information about the position of the body at the time of death, if the body has remained like that for long. The hue of the postmortem lividity can also give clues to deaths from poisons like opium or cyanide.

Rigor mortis, the stiffening of the muscles after death, is also governed by environmental factors and the emotional state of the victim prior to death. The stiffening is caused by the enzymatic breakdown of substances in the muscles. The lactic acid liberated during this process builds up because it is not removed by the blood (since circulation has stopped).

Rigor mortis, unlike lividity, involves the entire body. Stiffening, which commences within a couple of hours after death, is seen in the muscles of the jaw and face and proceeds towards the legs and feet. Generally, the whole body becomes stiff within about 12 hours, remaining so for another 12 hours. At this stage, the body is so very rigid that it could be rested horizontally like a board, with two supporting poles, one each under the head and feet. After this, the muscles loosen up again in about another 12 hours. A knowledge of these stages and the rates at which the muscles harden and soften can aid determination of the hour of death.

Cadaveric spasm

Instantaneous rigor, sometimes called cadaveric spasm, is a muscular spasm or contraction appearing instantaneously on death. It usually does not affect the whole body and involves a single set or group of muscles. Soldiers killed on battlefields have been found to develop cadaveric spasm affecting the entire body. However, this is not so in cases of homicide.

Cadaveric spasm is stronger than the rigor mortis and appears in deaths which are sudden and at the height of nervous tension. The muscles involved seem to suggest that the victim was engaged in violent or defensive physical activity at the time of death—the hand is seen tightly gripped to the gun as at the time of suicide, or clutching a lock of hair or a bit of the assailant's clothing.

Unlike rigor mortis, cadaveric spasm disappears only on decomposition of the body. Although it is not helpful in determining for how long a person has been dead, it often helps in understanding the circumstances of death. Because cadaveric spasm cannot be simulated, a murderer, in such cases, cannot easily fool the police by placing a weapon in the hands of the victim after killing him to make it appear like a suicide.

Another time indicator is the bacterial action that takes place within a body resulting in its decomposition or putrefaction. The action is in fact both chemical and bacterial. Chemical action is in the form of autolysis where the digestive enzymes and ferments, which normally act only on the food when a person is alive, now act on the body tissues like the stomach, the oesophagus and the intestines.

Initially, a greenish discolouration appears on the right side of the lower abdomen, gradually spreading to other parts of the body and developing a reddish hue. There is gaseous distension, due to biochemical degradation, and the body bloats. The veins stand out like the patterns on a marble floor. Blisters then form and the face cannot be recognised. On further decomposition, the body turns blackish. At this stage even racial distinctions become difficult.

Decomposed face after insects have laid eggs (24 to 36 hours after death)

Internally, the intestines are affected first, followed by liver and spleen, heart and lungs, brain and spinal cord. The prostrate and uterus are usually affected last. The body tissues gradually get liquefied and break down until only the skeleton remains.

Putrefaction is also affected by environmental factors. Warm climate hastens it, while the winter slows it down. Other factors affecting putrefactive changes are obesity, death following sepsis and external injuries —all of which hasten the process. Generally, as the rigor mortis disappears, decomposition starts, giving the forensic scientist a clockwork starting from 24 to 36 hours to as much as one week to a month.

Adepocere formation is a process where the soft tissues of the body are destroyed and slowly get converted into a cheesy, greyish-white matter. This is chiefly due to fatty acid formation which infiltrates other structures. And, being acidic, it inhibits the bacterial action responsible for putrefaction. This occurs in dead bodies which lie discarded in moist soil or water. It may take anything from three weeks to three months, sometimes even six months, for the phenomenon to develop. On the other hand, in a dry and warm atmosphere the body may wither, shrivel up, become a mummified structure with decayed internal organs.

Flies and other airborne insects often lay eggs and larvae develop on the mouth and other body openings. The life-cycle of these insects (which normally lay the eggs within a day following death) give clues, from the knowledge of their developmental stages, as to how long the person has been dead.

Internal examination

All the methods described so far are based on external examination of the body. Internal examination too helps. For instance, the quantity of food present in the stomach, its nature (with a knowledge of whether the person was a vegetarian or non-vegetarian), and its stage of digestion can point to the time that elapsed between the victim's last meal and death.

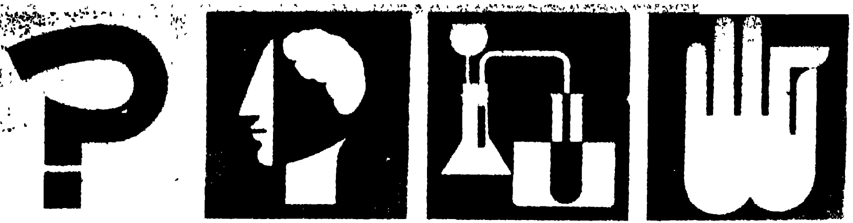
One notorious case where the time element played a crucial role in investigation was the Pune multiple murder case of 1977-78. The postmortem reports established that the deaths had taken place during a particular period following consumption of meals, and all within that period, also suggesting that at least two or three people were involved in committing the murders.

Recently, much work has been done on the rates of changes that occur in the various chemical constituents of the blood and other body fluids after death. Extensive studies have been carried out on blood glucose, which decreases after death on an average rate of 15 mg per cent per hour. Chemical changes occurring during an agonal period (just after the victim has been, say, shot or stabbed) in the plasma include increases in the amounts of potassium, lactic acid, phosphorus, magnesium and carbon dioxide. There is, besides, a decrease in blood pH and carbon dioxide combining power. More recently, changes in histidine (a compound present in hemoglobin) levels in the muscles have been studied using chromatography.

Studies on the vitrous humor (the fluid within the eyeball) has also shown promising results—a steady rise in the potassium content to the tune of 0.14 mEq/litre per hour after death. The technique is found to be useful 24 hours after death.

It is very important that all these methods of postmortem examination be done very carefully. For, even a small error in the medico-legal investigation can change the course of an entire case. The result would be justice thrown to the wind.

Dr. Phatnani, 38, who now heads the medical education wing of Glaxo Laboratories (India) Ltd, Bombay, has been a forensic surgeon since 1972 and has performed over 6,000 medico-legal autopsies.



Exhibition symbol/Design: Laxma Goud

The method of science
2

> *"The applications of science are inevitable and unavoidable for all countries and peoples today. But something more than its application is necessary. It is the scientific approach, the adventurous and yet critical temper of science, the search for the truth and new knowledge, the refusal to accept anything without testing and trial, the capacity to change previous conclusions in the face of new evidence, the reliance on observed fact and not on preconceived theory, the hard discipline of the mind – all this is necessary, not merely for the application of science but for life itself and the solution of its many problems."*
>
> Jawaharlal Nehru

Text©P M Bhargava

The method of science

The method of science consists of four distinct steps.

QUESTION
↓
HYPOTHESIS
(often called a theory)
↓
EXPERIMENT
↓
ANSWER

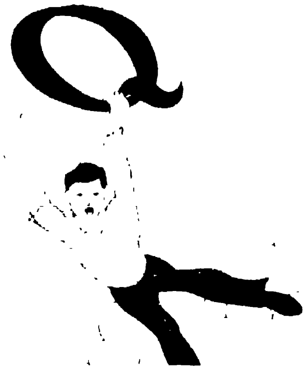
At each step mentioned above, and in going from one step to the next, we use existing knowledge, reasoning and imagination.

STEP 1 IN THE METHOD OF SCIENCE

The Question

The question may arise out of careful observation or careful analysis of existing knowledge

Q&A Q&A Q&A



Francis D'Sa

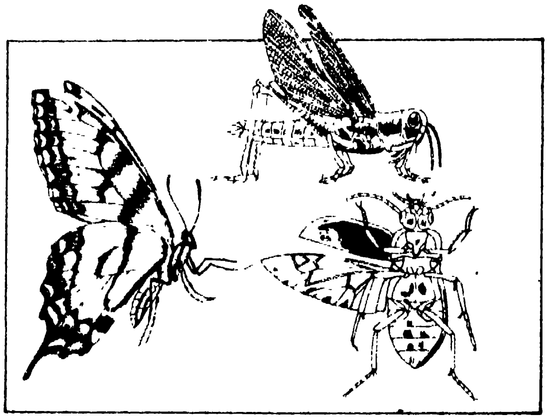
If you have framed your question properly, you are already on your way to finding the answer.

A well-framed question is one to which an answer can be found within the framework of the method of science. Such a question should lead to a hypothesis which can be tested by an experiment.

The more carefully you observe, the better-framed your question would be.

For example:

the observation is



Many living species (insects) have six legs

Well-framed questions would be:

- ★ how did these species come to have six legs?
- ★ do these species have other common features?
- ★ could these species have originated in nature from a common ancestor?
- ★ does the possession of six legs help the insect in any way?

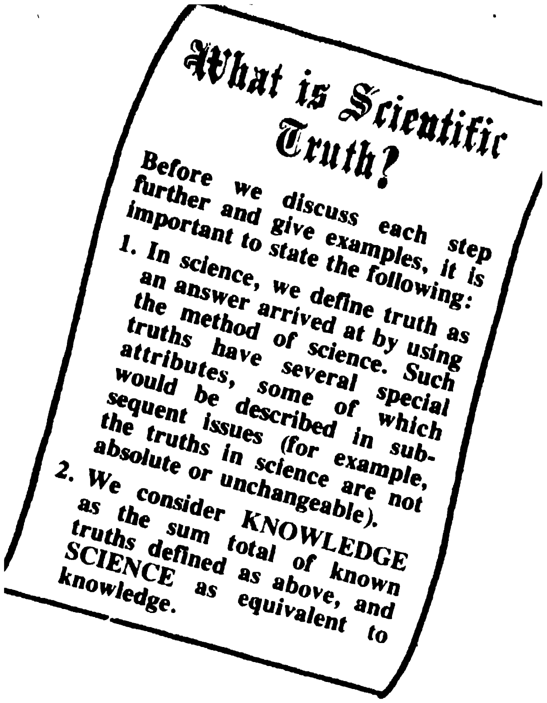
Questions such as the ones above led Charles Darwin to frame the theory of evolution which explains how so many different species have come to exist on the earth.

The caption to this 19th century cartoon published in Germany reads "Darwin in consultation with one of his ancestors"

The method of science allows us to obtain answers to questions. The ANSWER could take several possible forms.

For example:

- ★it could be in the form of A STATEMENT applicable only to the particular situation under study;
- ★it could be in the form of A GENERALISATION—often called a law — which is more widely applicable. At times the generalisation arrived at continues to be called a theory — the same theory that constituted the hypothesis — as in the case of the theory of relativity ,
- ★it could be in the form of A COURSE OF ACTION.



What is Scientific Truth?

Before we discuss each step further and give examples, it is important to state the following:

1. In science, we define truth as an answer arrived at by using the method of science. Such truths have several special attributes, some of which would be described in subsequent issues (for example, the truths in science are not absolute or unchangeable).
2. We consider KNOWLEDGE as the sum total of known truths defined as above, and SCIENCE as equivalent to knowledge.

Cha

STEP 2 IN THE METHOD OF SCIENCE

The Hypothesis

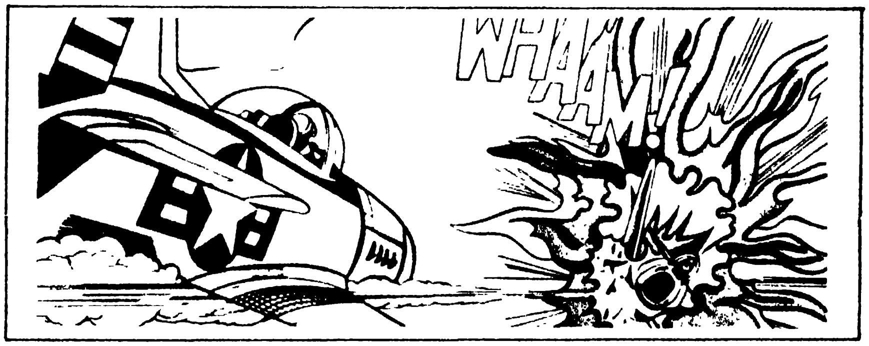
The hypothesis (an answer you consider possible) should be testable.

A testable hypothesis is one which can be tested by an experiment, or on the basis of which testable predictions can be made.

An example:

Observation

★ Objects if left unsupported above the earth will fall to the ground



"Wham", Roy Lichtenstein, Tate Gallery, London

Untestable hypothesis

★Things fall to the ground because God wills them to do so.

..AND LET THERE BE RAIN!

Padekar

Testable hypothesis

★An object falls to the ground because there exists a force of attraction between the object and the earth.

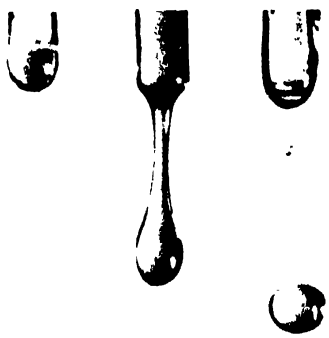
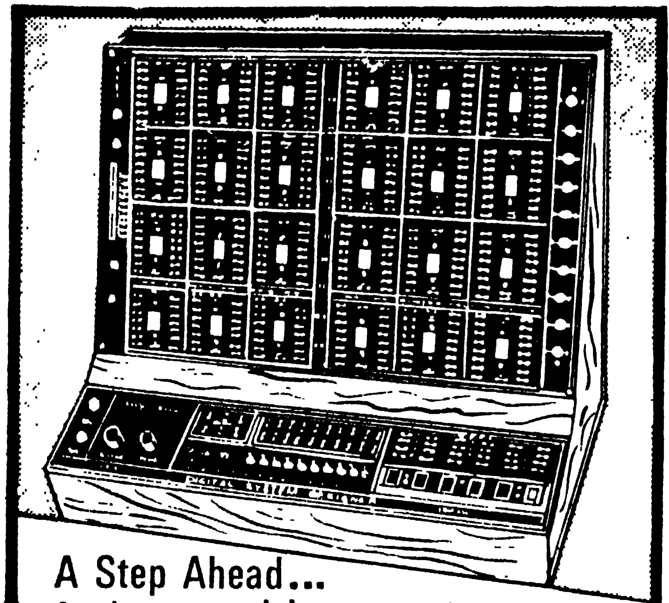


Photo Safia Mehdi

Starting with such a hypothesis, Newton arrived at his well-known law of gravitation, which states that any two objects attract each other, the force of attraction being directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

NEXT MONTH
STEPS 3 AND 4
in the Method of Science



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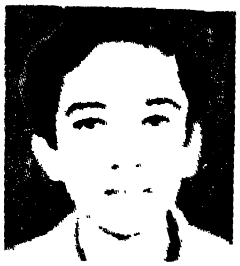
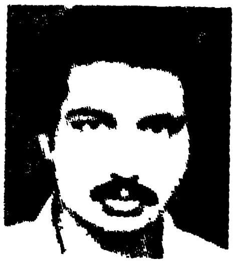


Sunil Kumar Bansal
1st in Medical Entrance Delhi '77



Raghavendra Goswami
1st in Medical Entrance Wardha '77

Bhupinder Bhandari
1st in Medical Entrance Delhi '78

Rajiv Verma
2nd in Medical Entrance Delhi '78

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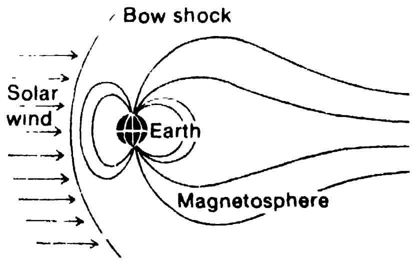
...there was no magnetism on earth

IF ANY of the natural phenomena, observed on the earth, were to be nonexistent or drastically different, several (or perhaps all) of the fundamental laws would be in jeopardy. As a consequence, the universe would be inconceivably different from what it is.

Even a simpler proposition, that is the sudden vanishing of any natural phenomenon, would cause strange events and unexpected upheavels. This would be true even if we take a very innocuous-looking example, like the vanishing of the earth's magnetic field. But, first, what is the earth's magnetic field due to?

From measurements of the field at the earth's surface it appears as though there is a bar magnet sitting at the centre of the planet—that is, the field is approximately that of a dipole. But we know that there is no bar magnet sitting at the centre of the earth; it is too hot there for any material to retain its magnetism. Though the exact mechanism is not known, it is believed that the field arises from convection currents in the highly conducting core of the earth. It is possible to conceive of convection currents (maintained by radioactive heating) such as those that result in a self-stimulating dynamo (which generates its own magnetic field). Of course, the basis of all this is the fundamental law that there is always a magnetic field associated with an electric current.



The dipole field of the earth should normally extend to infinity. But it does not. The highly conducting hypersonic solar wind (consisting mainly of electrons and protons at a density of a few particles per cubic centimetre) restricts the magnetic field to a cavity around the earth called the 'magnetosphere'.

Now if the earth were to have no magnetic field, we shall have to accept one of the two following suppositions: first, an electric current need not have a magnetic field associated with it. Second, there are no convection currents in the core of the earth (as appears to be true in the case of moon).

The first supposition is too drastic to contemplate. The universe would be completely different, but what it would be like is difficult to conceive.

And the second supposition would perforce require that we accept that the whole thermal history of the earth was different from its actual, akin maybe to that of the moon. This would mean that the earth's evolutionary history, which is linked intimately to its thermal history, would also have to be very different—perhaps there would be no *Homo sapiens*.

Now, let us consider a less drastic proposition, that a supernatural power somehow switches off the earth's magnetic field today. What would happen? Nothing very much, one may think. After all, the magnetic field is an abstract thing. Nature has not even considered it necessary to develop an organ in the human body to perceive it. We do feel gravitational pull, have ears to hear sound, can sense heat and have eyes to see objects when light is reflected from them. We can also observe electricity; lightning, after all, is a manifestation of electricity. And we feel a shock if an electric current passes through body. But, in order to observe magnetism we need instruments. Is it then odd for anyone to think that even if such a thing vanishes, it should not really matter?

The magnetic field, by itself, is abstract and acts in subtle ways. But often it generates effects which are quite gross and observable. If the magnetic field is suddenly switched off, the immediate effect on earth would be the loss of the magneto-sphere and the radiation belts where electrons and protons of energies ranging from a few electron-volts to millions of electron-volts are trapped. The brilliant aurorae, which result from the precipitation of these particles in polar regions, will be gone. Or, perhaps, we will observe faint aurorae all over the earth when solar wind impinges unhindered on the ionosphere. But this is merely a change in visual effects, and perhaps not of much consequence. More drastic will be the effect on the weather and other atmospheric phenomena, caused by solar particles and by enhanced flux of cosmic rays.

At present, the earth's magnetic field deflects away the low-energy cosmic rays (which are far more abundant than the high-energy ones) from the lower latitudes. In the absence of a magnetic field, the flux of cosmic rays in tropical regions would increase to the same level as in polar regions. This should ionise the tropical atmosphere to the same extent as the polar, thus upsetting the state of atmospheric electricity and weather. Further, more radiocarbon would be produced in the atmosphere, which would eventually raise the quantity of radiocarbon in all living matter. What consequences this may ultimately have is hard to guess. Indeed, there is evidence that during geologic times, once in a while, the polarity of earth's magnetic field has reversed. The earth's magnetic field may become zero for a short while (maybe for a thousand years) during such a flip over. This could have been the basis for evolutionary jumps in certain species.

Coming down to more mundane things, the compass would cease to have use in navigation. the sailors would have to revert back to the heavenly bodies, for directional aid. Some birds, fish and honey bees which are supposed to orient their flights with the help of the earth's magnetic field will have a hard time. But electric generators and motors should continue to work, as here we have considered the vanishing of earth's magnetic field only, not the invalidation of Faraday's laws.

RAMA

Prof Rama is with the Hydrology Group, Tata Institute of Fundamental Research, Bombay

Brain Teasers

The Kite Flier:

My young nephew is so crazy about kites that he makes them himself in lots. The other day he was showing me stacks of red and blue kites that he had just made. He had worked out their cost also.

"For less than five rupees I have as many kites of each colour as the price per kite of that colour in paise. The reds cost 93 paise more than the blues," he added.

I could not figure out how many kites of each colour there were. Could you?

N.A. JAGANI

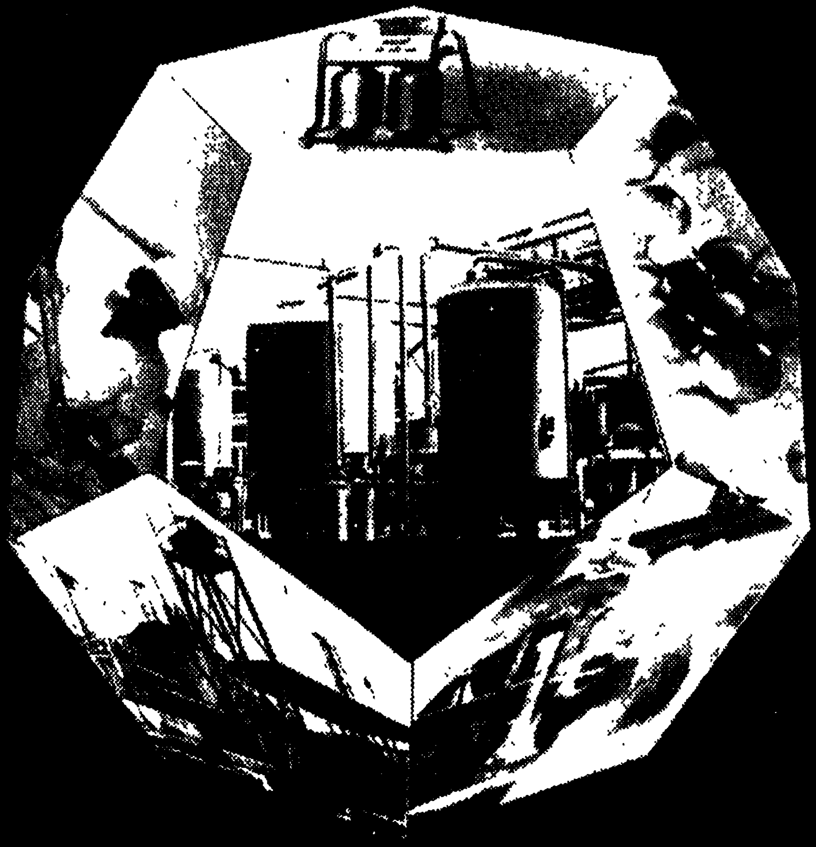
Solution to last month's Brain Teaser

Landlords and Tenants

Sunder's house was not Sunder Mahal; and it was not Balaji Mahal, since Balaji bought it; neither was it Arun Mahal, since it would mean that the house owned by Arun was bought by Arun! So Sunder's house was Ashok Mahal, which is bought by Balaji. Arun's house could not have been Arun Mahal, Ashok Mahal, (which was Sunder's) or Sunder Mahal. So it was Balaji Mahal that was bought by Ashok, the former owner of Sunder Mahal; so Balaji was the owner of Arun Mahal in the old set-up. Now, Sunder has to buy Arun Mahal and Arun, Sunder Mahal. The two set-ups are as follows:-

Building	Ashok Mahal	Balaji Mahal	Arun Mahal	Sunder Mahal
Old Owner	Sunder	Arun	Balaji	Ashok
New Owner	Balaji	Ashok	Sunder	Arun

What keeps us ahead of the others?



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The Bombay Mathematical Olympiad (Finals)

MATCH YOUR wits with the schoolboys.

We give below the questions asked at the finals of the Bombay Mathematical Olympiad held on 15 December 1979 at St Joseph's School, Colaba, Bombay. Thirty-one of the ninth and tenth standard students who participated in the preliminary test (see SCIENCE TODAY, January 1980) qualified for the finals. Three of the finalists won first prizes.

The winners were Dinesh Gopalan of Fatima High School, Amol Mhatre of Parle Tilak Vidyalaya, and G. S. Shah of Don Bosco High School. They averaged seven correct answers, which was not bad considering that they had no model papers to prepare for the test nor any knowledge of what they would be asked. Try working out the questions and, if you are an adult with an interest in mathematics, see how you would rate with the schoolboys.

All the questions below carry five marks each. The maximum time allotted at the competitions was two hours.

1. Show that the product of four consecutive integers is divisible by 3 and 8.

2. Find an integer n which leaves remainders 2, 3, 4 when divided by 3, 4, 5 respectively.

3. Find positive integers a, b, c, d (all distinct and ≤ 12) for which

$$a^3 + b^3 = c^3 + d^3$$

holds.

4. For any positive integer n, show that 9 divides the sum of the cubes

$$(n-1)^3 + n^3 + (n+1)^3.$$

5. For any integer m, show that there exist integers n and N for which

$$(m^2+1)(n^2+1) = (N^2+1)$$

holds. (Ignore the trivial case of $n = N = 1$.) Deduce that the product of 4 consecutive integers cannot be the square of an integer. (Use the identity

$$a^2 - b^2 = (a-b)(a+b)$$

and express n and N in terms of m.)

6. Show that $\log_2 6$ is not a rational number. (Proof by contradiction.)

7. Using the fact that for any natural number $n > 1$, it is a product of primes, prove that

$$\log_{10} n \geq k.\log_{10} 2$$

where k is the number of prime factors of n.

8. Find the sum of all the coefficients of the polynomial

$$(x-1)^4 (x-2)^2 (x-3) (x-4).$$

(A polynomial is an expression of the form $a_0x^n + a_1x^{n-1} + \dots + a_n$ where $a_0, a_1, \dots, a_n$ are all numbers and x is a variable, and a_i are called coefficients of the polynomial.)

9. Prove that any quadratic polynomial $Q(x) = ax^2 + bx + c$ can be put uniquely in the form

$$Q(x) = k.\frac{x(x-1)}{2} + l \cdot x + m$$

where k, l, m depend on a, b, c.

Show that if Q(x) takes integer values for integral values of x then k, l, m are integers.

10. If S is a subset of the set $\{1, 2, \dots, 2n\}$ having $n+1$ elements, then S contains at least two consecutive integers x and $x+1$.

11. If $\{s_1, s_2, \dots, s_n\}$ (n odd) is a rearrangement of the set $\{1, 2, \dots, n\}$ show that the product $(s_1-1)(s_2-2)\dots(s_n-n)$ is even.

12. The set $\{1, 2, 3, 4, 5\}$ is divided into two disjoint subsets. Show that for every such division, at least one of the subsets contains two numbers and their difference.

13. Given a_1, b_1, c_1, d_1 each of which is either 0 or 1, call the absolute values of the differences

$|b_1 - a_1| = a_2$, $|c_1 - b_1| = b_2$, $|d_1 - c_1| = c_2$, $|a_1 - d_1| = d_2$

and

$|b_2 - a_2| = a_3$, $|c_2 - b_2| = b_3$, $|d_2 - c_2| = c_3$, $|a_2 - d_2| = d_3$.

Define a_i, b_i, c_i, d_i in terms of $a_{i-1}, b_{i-1}, c_{i-1}, d_{i-1}$ similarly. Show that after finite number of steps, $a_m, \dots, d_m$ are all 0. (By absolute value $|n|$ we mean n if $n \geq 0$ and $-n$ if $n < 0$.)

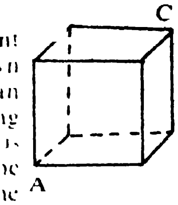
14. In a high school class of 30 pupils, 12 like mathematics, 14 like physics, and 13 chemistry, 5 like both mathematics and physics, 7 both physics and chemistry, 4 both mathematics and chemistry. There are 3 who like all the three subjects. How many do not like any of the three subjects?

15. Prove that if a pentagon inscribed in a circle has equal angles, then its sides are equal. Is this true for any polygon of n sides?

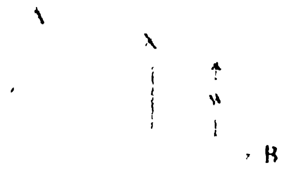
16. In a regular hexagon $A_0A_1A_2 \dots A_5$ inscribed in a circle of radius 1, show that the product $A_0A_1 \times A_0A_2 \times \dots \times A_0A_5 = 6$.

17. Using Pythagoras's theorem, give a geometric construction (by means of ruler and compass) for getting $\sqrt{m}$ for all positive integers m.

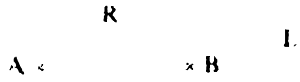
18. A lizard at the point A in the cube shown wants to catch an insect at C. Assuming that the insect is stationary what is the shortest path that the lizard should take to reach C? (This lizard cannot jump or fly!)



19. A and B are two points on either side of a canal of width w. Find the point X on the bank of the canal at which a bridge should be built so that the distance for the traveller from A to B is the least. Note that the bridge has to be perpendicular to the canal.



20. A and B are two points on the same side of a wall L. Find the point R on the wall L so that AR + RB is the least as R varies along L.



The paper was designed and evaluated by
S. S. RANGACHARI
R. SRIDHARAN
S. SRINIVASAN
School of Mathematics, Tata Institute of Fundamental Research, Bombay

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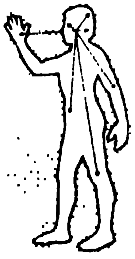

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...how can some animals digest grass?

MOST OF us have been told as children that a cow has four "stomachs". Well, to be precise, the cow has a stomach with four chambers, and therein lies the answer to our question.

If it were possible for humans to digest grass, like the cow and other ruminants, many poor nations of Asia and Africa could have solved their acute problems of food shortage. But then, man simply isn't equipped to digest grass because the main component of its cell-wall is cellulose, a polysaccharide; what our bodies lack is an appropriate enzyme to hydrolyse, or split up, the cellulose.

Strange as it may appear, even the digestive glands in the cow's stomach do not produce any such enzyme. But why take only the cow? In fact no animal, not even the common wood-boring insects that feed exclusively on wood — on cellulose, that is — produce such an enzyme. How then do they digest cellulose?

On their own, these animals cannot digest grass. They need the help of micro-organisms. You might call it external help from inside. For, innumerable (some 15 to 20 million per cu cm) microbes — mainly bacteria — reside within their very spectacular stomachs. These microbes secrete certain enzymes, collectively termed as *cellulase*, which have the property of splitting up the undigestible cellulose. In cows, which are the best examples of ruminating animals, these microbes have their colonies in the rumen (or paunch), which is the first and the largest of the four chambers of the stomach. The rumen also serves as a sort of vat for fermenting the split-up cellulose. The other three chambers are the reticulum (honeycomb), the omasum (psalterium or manyplies) and the abomasum. Of these, only the last one has a glandular wall (with its digestive juices and absorptive layers) and corresponds to a true stomach.

But, coming back to the rumen, the microbes there live it up, fattening themselves and multiplying at a tremendous rate, feeding greedily on the food taken in by the cow.

How then, you might wonder, does the cow obtain its nourishment? Simple: ready digestion of the micro-organisms themselves in the next and subsequent sections of the stomach and in the intestines. But that is not all. The rumen microbes also produce glucose, amino acids, fatty acids and other substances. These, the cow can absorb directly into the blood.

Why not then feed the cows directly with these microbes? The hitch lies in the fact that nothing suits these ruminants better than the natural fodder for their protein and energy requirements. Direct culturing of micro-organisms on farms as cattle-feed to provide them with an alternative source of protein has been tried out in some countries for pigs with some measure of success. Perhaps the day is not far off when much of the fodder for farm animals would be produced not in fields but in factories

But we already have such synthetic substitutes as urea and carbamide. Urea, as you might already be aware, is a waste arising from protein metabolism, and is not entirely foreign to the animals. Carbamide, which is also another breakdown product of protein metabolism, has been used in Germany and the Soviet Union as cattle-feed

In the cow's rumen, the carbamide is hydrolysed to ammonia, from which, in turn, microbial protein is synthesised to give the animal additional nutrition. Carbamide when fed to milch cows increased their yield considerably; similarly, the quantity of beef also went up. In the case of sheep, the wool produce shot up remarkably. But, then, all this is not without problems. Any excess of carbamide fed to the animals may lead to the micro-organisms not having sufficient time to use up all the ammonia formed in the rumen. And that could lead to poisoning, because ammonia is a toxin. Carbamide must, therefore, be given with care

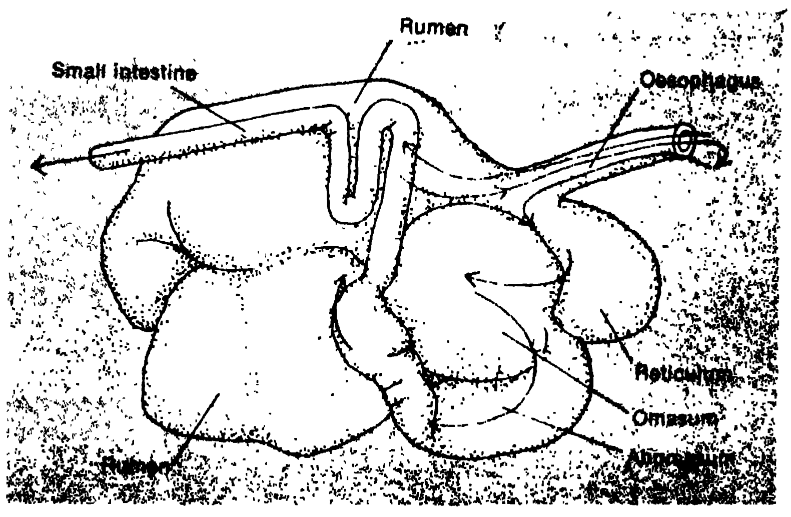
There are times when nature thinks it fit to conserve even wastes. Waste products of protein metabolism are constantly made use of by animals that live in deserts, who have, at all times to face food and water shortages. A thirsty, starving camel excretes very little or no urea. The urea produced within finds its way to the stomach — the microbe-producing mill — where proteins are synthesised from it. But farmers should remember that, like carbamide, excess urea too can be deadly. So, while using urea to supplement natural fodder, strict control should be exercised in order to avoid mass-poisoning. But protein substitutes, urea phosphate and urea glucosyl are safer and their use has yielded good results.

With so much understood, would it be possible to transfer these cellulose-digesting genes to *E.coli* and other bugs that reside in man's digestive tract so that we may digest grass? Several problems will be encountered, even if the transfer is carried out successfully. First, the organism may not be able to compete with the normal flora of the intestinal tract and, therefore, will fail to establish itself in the tract. Even if it can colonise the tract successfully, the digestion of cellulose in the humans may produce excessive carbon dioxide, which may not be easily expelled. Besides, it may make the tract more acidic and who knows, cause more ulcers! The important point to remember is that natural selection often operates over a group of characters rather than over individual characters. Thus, in the case of the cow, the structure of its teeth, tongue and stomach, and the ruminating bacteria have been all selected as a group of effective digestion of cellulose. And, simply introducing the cellulose-digesting bacteria in humans may not be a proper unit of natural selection.

It is interesting to note that an infant ruminant, a calf for instance, has a very underdeveloped rumen and during its first few weeks of life, the digestive processes resemble that of other mammals having simple stomachs. Only as the calf begins to graze does its rumen enlarge and the microflora develop. Perhaps oral contact with older animals help in inoculating the bugs.

B S MAHAJAN

Dr (Mrs) Mahajan is on the editorial staff of SCIENCE TODAY



Stomach of cow showing the different chambers

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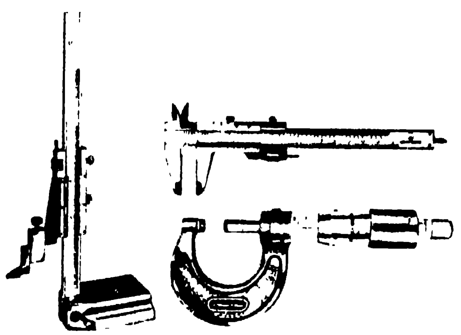

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Of fatigue and productivity

*Krish Pennathur

THE EFFICIENCY of a work system depends not only on the capabilities of the worker and the effectiveness of the equipment he uses, but also on his capacity for *sustained* performance. Prolonged work results in fatigue which impairs the person's efficiency. Since fatigue has to be compensated for by proper pauses for relaxation, the effective time at actual work gets reduced.

Fatigue as a subject has long attracted the interest of engineers, physiologists, psychologists, biologists, industrial engineers and ergonomists. It is an important factor in any work system and is generally understood in terms of its effects such as a feeling of tiredness, weariness, exhaustion, and the inability to cope with the normal tempo of work. But what 'fatigue' really is has yet to be clearly defined. There is a consensus, however, that fatigue-causing factors can be broadly classified into such distinct categories as involving physical energy output, perceptual energy expenditure, psychomotor tasks and mental work on the one hand, and psychological effects caused by boredom, lack of work, waiting, etc on the other.

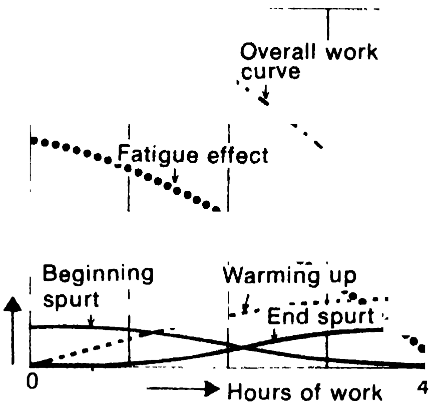
Different types of fatigue are perceived in different work situations or work systems, but any type of work can cause any type of fatigue. To complicate the matter further, there is yet another factor called 'motivation'. With high motivation, the types of fatigue that are normally expected do not occur. But, at low levels of motivation, several types of fatigue appear long before they should. The most vexing aspect is that fatigue *per se* cannot be measured. At best, its effects can be quantified.

Effects of fatigue

Quantitative changes: In any work involving physical energy expenditure, be it static or dynamic, the output varies with the length of time at work. The longer the work period, the less is the output. Thus, a person who can load five tonnes of cement in the first hour will be unable to keep up that output rate during the succeeding hours. In one study, the rate of loading was found to fall from four tonnes in the first hour to one-and-a-half tonnes in the eighth hour.

Time for performance: In an experiment conducted at a tin-smith shop by the author, the output rate over a five-hour work period remained fairly constant because of the high degree of motivation that prevailed at the shop. But, to keep to the standard performance, the energy expenditure increased hour after hour. The energy output which in the first hour was 7.1 kilocalories rose to 11.6 kilocalories in the fifth hour! Thus, although the quantitative output remained apparently constant, the performance efficiency kept dropping since greater and greater effort had to be put in to maintain the initial rate of output.

Fig1.



Qualitative changes: In a study conducted at New Delhi, the performances of nine highly rated typists were recorded for four continuous hours in the morning and three continuous hours in the afternoon. The average number of errors made, for every 300 words typed, was one in the first hour, 1.4 in the second, 2.9 in the third and 5.6 in the fourth hour. In the afternoon, the average started with 1.3 in the first hour, 2.7 in the second and 5.9 in the third. A similar pattern was observed in the performances of hand-operated lathe-workers in a light-machine shop at Thane, Maharashtra, except that the average number of errors increased more steeply in the afternoon work.

Physiological effects: A study undertaken in 1959 by the US Public Health Service on about 700 truck drivers showed a decrease in the heart-beat rate and a slight increase in the blood pressure with longer hours of continuous driving. Hand-steadiness of the drivers also decreased with increased hours of driving.

Another physiological change that occurs with the onset of fatigue is the increase of unnecessary movements among operators. This may take the form of fumbling with levers, knobs and controls. Under stresses of static physical load, the operator may make such unnecessary movements as walking away from the desk or looking out of the window just to relieve the fatigue.

Variability in performance: A good way of describing 'variability' will be to recount the performance of a soldier practising at a firing range. Given a target, his first shot may straight away hit the bull's eye. But as the time passes, his aim may fluctuate. It may hit the right edge of the outer ring, then the upper edge of the inner ring, then the bottom-left of the outer ring, and so on. If one takes the mean of these performances, the soldier may be considered to have scored very near the bull's eye. Only there has been considerable inconsistency in his performance. Indeed, variabilities like these do occur in almost any type of work. And if the work is continuous, the variabilities may increase sharply after the first two or three hours.

Other effects: That accidents tend to increase with increasing hours of continuous work was amply substantiated by a study of the performances of crane-drivers at a factory in Calcutta.

Table 1

Factor	Relaxation allowance (Percentage of basic time)
Energy output	
Light bench work - seated	0-6
Light bench work - standing	6-8
Light shovelling work	8-12
Hacksaw or filing work	10-20
Swinging a heavy hammer	20-30
Loading heavy weights	30-80
Posture	
Normal sedentary work	0-1
Standing erect	1-3
Standing, operating a foot control	3-6
Crouching position	4-10
Motions	
Limited swing of hammer	0-5
Working with arms above the head	5-10
Working at a thin coal seam	10-15
Visual fatigue	
Reading meters or gauges	0-2
Precision machine work	1-2
Visual inspection (varying focus)	2-5
Visual inspection (fixed focus)	4-8
Aural fatigue	
Continuous low hum (low drone of the air-conditioner)	1-2
Moderate intermittent noise	3-5
Heavy continuous noise	4-6
Heavy intermittent noise	5-8
Personal needs	
Normal requirements	2-5

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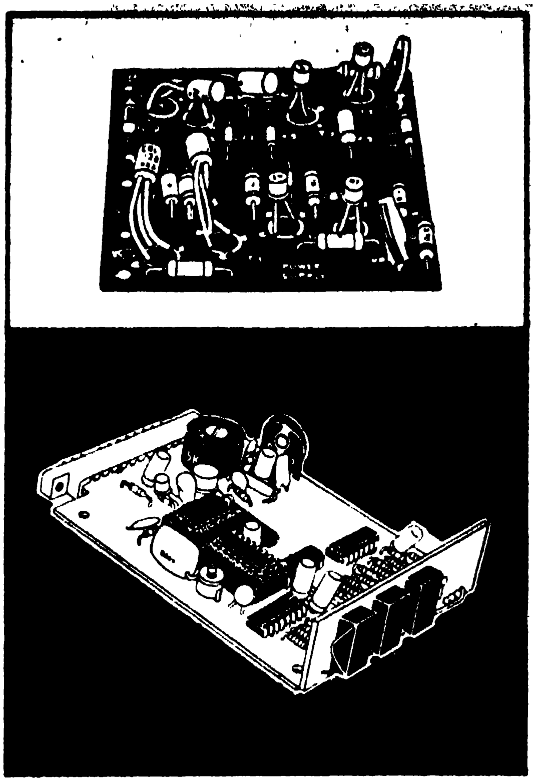

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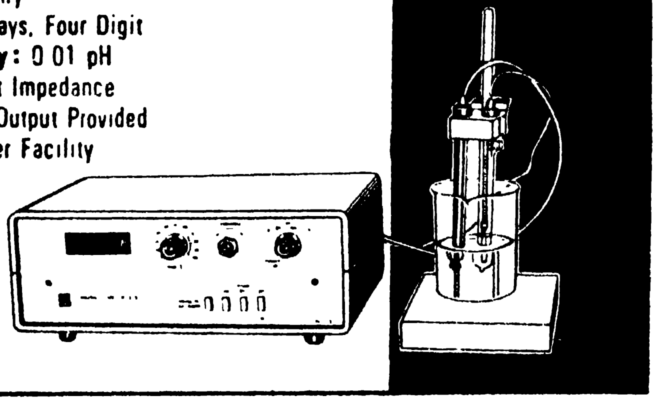
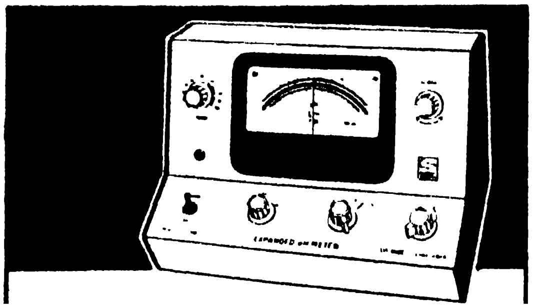


SYSTRONICS pH METERS



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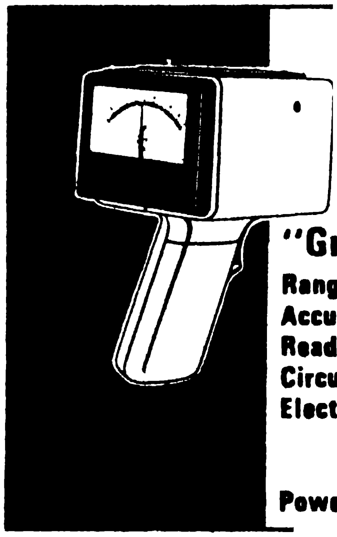

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In psychomotor work, the physical effort called for is not much. But coordination between sensory inputs and physical motor outputs (like throwing 'off' the switch when the red light glows, or moving a knob to keep the pointer at a pre-determined position) is of prime importance. This coordination gets impaired with prolonged working hours. The reaction time of the operator which is the time taken by the human mind to receive a signal (like a warning light or an alarm signal), interpret its significance and choose the course of remedial action, increases with the number of hours of work. There is a perceptible lag between sending the sensory message to the brain through the nerves and the brain sending out internal signals to the muscles to take the corrective action.

Another effect, attributable to perceptual fatigue, is eye strain. Errors in reading the dials, indicators and gauges, decreasing visual acuity, misreading of numbers and letters, distraction through watering of the eyes, imagining specs (on the radar screen) when there are none and inability to focus are some of the results of long hours of eye strain. Some studies indicate that hearing power also decreases with increased hours of work.

The number of hours worked on a day influences the performance of a person at a given time. One is the 'beginning spurt'. Generally, an individual is full of enthusiasm when he begins a task. This gradually peters out as the hours go by. Similarly, there is an 'end spurt' when a person summons up all his energy to clear away the pending work. This is akin to the extra effort put in by the sprinter in the last 10 metres of a 100-metre race. There is also a 'warming up' effect: an individual starts slowly and gathers momentum as he goes along. If all these factors are taken into consideration, the work curve of an average individual in a normal work situation would be as shown in Fig. 1.

Phasing the rest pauses

Rest pauses help to recover from fatigue. But the more a person is fatigued, the longer it will take him to recover. Also, the rate of recovery which is rapid in the beginning drops off with time. While it takes a fairly long time to recover from complete exhaustion, a partial recovery may take only 10 minutes. The rate of recovery from total fatigue is represented in Fig. 2.

The work schedule should, therefore, comprise alternating periods of work and rest. A good method of preventing the ill effects of fatigue is to have a rest pause before fatigue becomes apparent. Recovery would then be speedy (Fig. 3). The second rest pause should be longer than the first and the second spell of work slightly shorter than the first. The starting production rate after each pause is always lower for each successive spell of work.

Rest pauses may be spaced according to the convenience of the operator or during the scheduled timings. There is evidence to show that production increases if rest pauses are 'scheduled'. A practical recourse would be a combination of the two. Normally, rest pauses should be more frequent during the latter half of the working day. Actual scheduling of rest pauses for any specific type of work would relate to the performance curve pertaining to that work. As pointed out before, a rest pause must be introduced before the production rate drops. This is generally about an hour-and-a-half after commencement of work. This process should be continued throughout the day, so that a schedule of rest pauses can be formulated. The duration of the rest period would vary from work to work and, sometimes, with the hour of the day.

There is another aspect of work study which aims at establishing the equitable time required for the performance of a task. It is to enable a normal worker to maintain his average level of work over the whole day and sustain it day after day without any detriment to his health. This is done by adding to the basic time needed for the performance of a task a 'relaxation allowance'. It enables the worker to recover from the fatigue effects of a work system. The relaxation allowance forms a percentage of the time actually spent on work.

Various factors are taken into consideration while reckoning the relaxation allowance. Some of these are: energy output, posture, motions, visual fatigue, noise, personal needs, thermal stresses, atmospheric effects, altitude and environmental conditions. The normal range of allowance for *each* factor is given in the Table.

There are various factors which may have a bearing on the volume of work turned out. Contrary to popular belief, more hours do not mean more overall increase in production.

A reduction in the number of hours worked per week has been found to increase the total output. The logic behind this would be obvious if it is seen that the total output is the product of output per hour and number of hours worked. As the number of hours worked increases, the output per hour drops, appreciably so after a certain number of hours.

Hence, to obtain maximum total output, the number of working hours must be optimal. In heavy manual work, reducing the number of hours of work per week from 67 to 55 in one instance resulted in an increase of 37 per cent in the rate of output and an increase of 19 per cent in the total volume of output. The effect is not so pronounced in lighter work. In order to maximise the output of a worker, the number of hours he must put in per week should be around 45 hours. Where maximisation of machinery utilisation is of importance, shift work should be resorted to.

Fig 2 The rate of recovery from total fatigue. Partial recovery may take only 10 minutes, while it takes fairly long to recover from complete fatigue

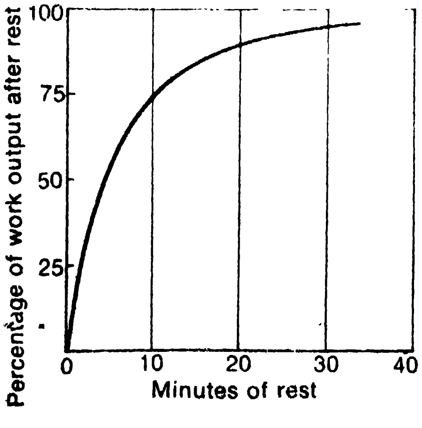
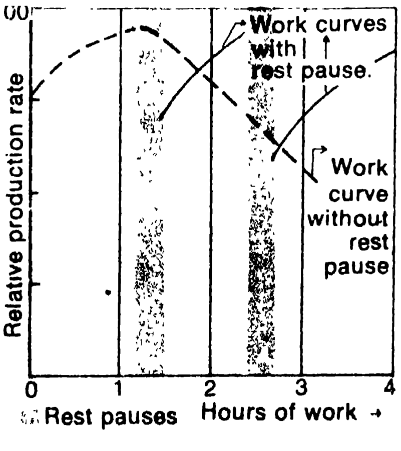


Fig 3 The dotted line represents the relative production rate without any rest pauses If a rest pause is given, the resultant work curve would be as shown by the continuous curves



Dr. Pennathur is currently coordinating the Commonwealth Research Programme on Standard Rate Performance of workers He is also engaged on certain facets of ergonomic research based on the Indian socio-industrial environment

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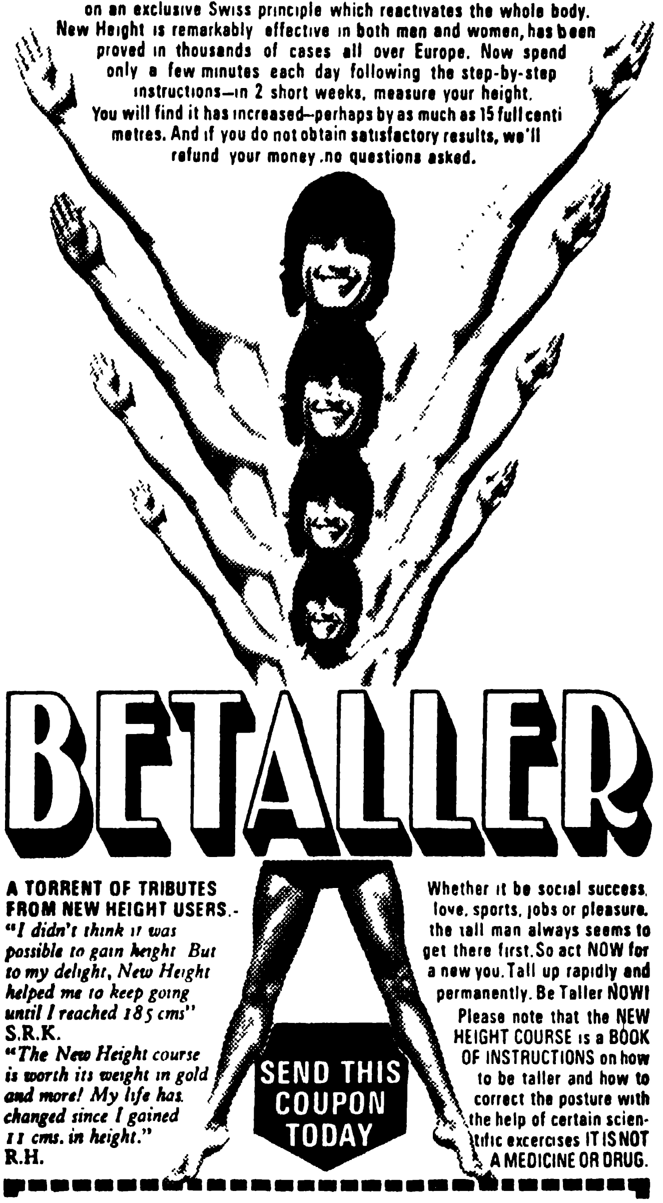

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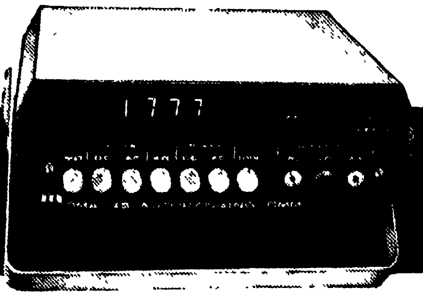

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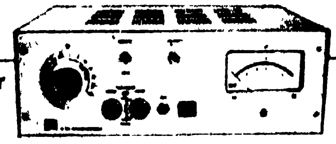

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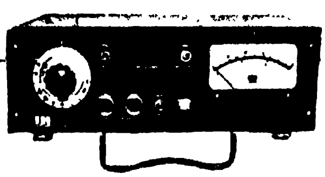

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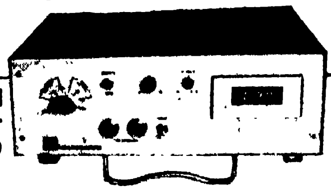

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IC tuned whistle switch

VIRTUALLY all electronic instruments have a filter of one form of other. The filter discards the signals which lie outside the desired band of frequencies. The functioning of radio, television, telephone, tape recorder and radar would be almost impossible without a means of separating desired frequencies from undesired ones. The network of components which does this frequency discrimination is called the filter.

There are mainly two types of filter networks, low pass and high pass. The low pass filter allows signal frequencies lower than a certain value to flow freely. The higher frequencies are bypassed to ground. The high pass filter works in exactly the opposite way, it bypasses frequencies lower than a certain value and allows only higher frequencies to flow through the network.

Different combinations of such low pass and high pass filters make two additional type of filters called Bandpass and Bandstop. The Bandpass filter allows only certain bands of frequencies to flow througt it and bypasses all other, higher and lower frequencies, to ground. The Bandstop filter, in a similar way, allows all the lower and higher frequencies to flow except certain bands of frequencies which are bypassed to ground.

The whistle switch described below uses a twin-T or parallel-T network for a particular frequency band selection. The filter network consists of two unlike T networks consisting of resistors and capacitors. No output is obtained, at a particular band of frequencies when the circuit impedance of the individual 'T branches are so arranged that the transmission, that is, the flow of signal through the two T networks to the output terminal is equal in magnitude and opposite in phase. For all other signal frequencies, lower and higher than the particular selected band, the twin T network does not provide much opposition. The figure shows the twin-T network and the formula for the mean frequency around which the bandstop function occurs.

The first stage of the whistle switch uses a loudspeaker as a microphone to convert the sound waves striking it into corresponding electrical signals. These electrical signals are amplified by the integrated circuit pre-amplifier stage using IC 741C operational amplifier. The 100K potentiometer in the negative feedback circuit of the operational amplifier is for controlling the amplification provided by this stage.

The second stage of the device also uses integrated circuit operational amplifier IC 741C. This stage has the twin-T network in its negative feedback. As the twin-T network is the bandstop frequency discriminative network, it provides virtually no negative feedback at bandstop frequencies and thus the operational amplifier provides very high gain at these [illegible] other, higher and lower, frequencies the network provides sufficient negative feedback and the amplifier is prevented from providing much amplification. As the normal whistle frequency is around 1.5 KHz the resistors and capacitors in the twin-T network are so selected to provide 1.5 KHz as the bandstop frequency. The amplifier stage thus discriminates between all other frequencies and amplifies only the frequency band around 1.5 KHz.

The output provided by the above stage is rectified and filtered to provide the necessary DC base signal to the Darlington pair driving the relay.

The last stage of the device is the power supply. The positive and negative half wave rectification from 22.5V AC transformer secondary provides 25V DC supply for driving the relay coil and 12V supply for the two IC 741C operational amplifiers.

The frequency selective characteristics of the prototype device provides output of 10Vpp (peak to peak sine wave measurement) at 1540 Hertz for 1 mVpp input signal. The output dropped to 5 Vpp for the same 1 mVpp input at 1500 and 1650 Hertz. In the same way, the output dropped to 1 Vpp for the same 1 mVpp input at 1100 and 2050 Hertz.

You will need :

Semiconductors : Integrated circuits 741C 2 Nos.; Transistors BC 107 - 1 No.; SL100 1 No.; Rectifier BY125 or BY126 - 3 Nos. BY126-3 Nos.

Capacitors: Electrolytic: 250 mfd, 35V 1 No.; 100 mfd, 35V-1, 100 mfd, 25V-1 No.; 50 mfd, 25V-2 Nos.; 25 mfd, 25V-1 No.; Polyster· 0.01 mfd-2 Nos.; 0.02 mfd-1 No.

Resistors (all ½ watt types) : 22K - 1 No.; 10K - 8 Nos.; 1.2K - 1 No.; 1K - 7 Nos.; 47 ohms - 1 No.

Potentiometer : 100K carbon linear or wire wound - 1 No.

Loudspeaker : 8 ohms permanent magnet miniature type - 1 No.

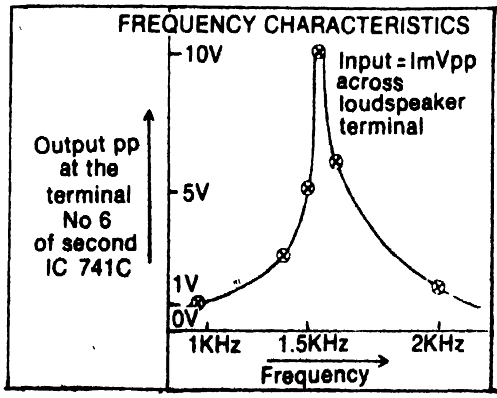
Approximate cost of the above electronic components in the Bombay market is Rs. 85/-

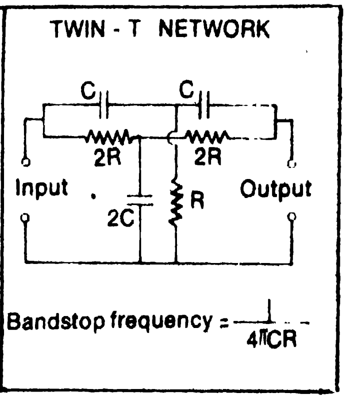
Relay : 24V DC coil, resistance more than 500 ohms with at least one changeover contact - 1 No.

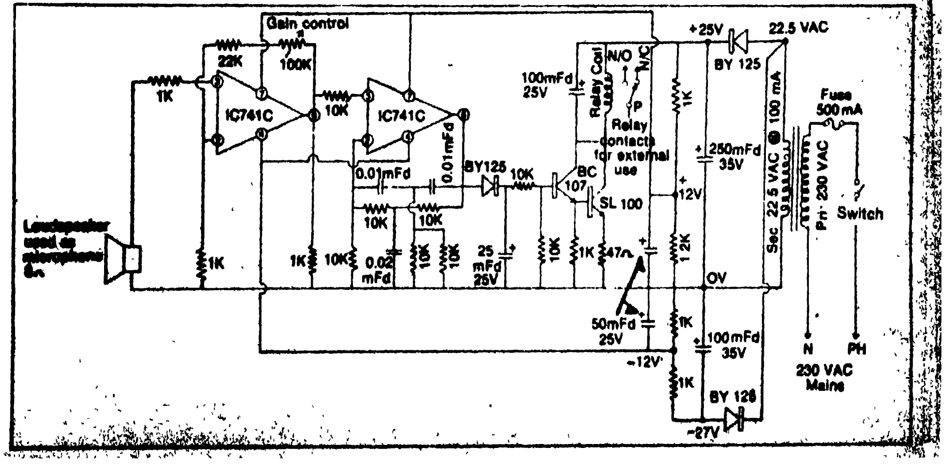
Transformer : Primary : 230V AC. Secondary : 22.5V AC 100 mA - 1 No.

Misc. : ON/OFF switch, fuse holder with 500 mA fuse, connector strip, shielded wire, IC experimenter's vero board, solder, wires, screws & nut, suitable enclosure.

ANIL V. BORKAR







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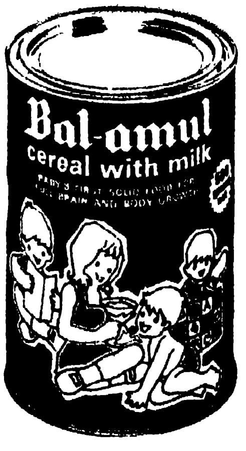

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Bhatnagar awards

THE COUNCIL of Scientific and Industrial Research (CSIR) has announced the names of 18 scientists who are to be awarded the Shanti Swarup Bhatnagar prizes for 1978 and 1979. The awards carry a citation and Rs 20,000 in cash.

Winners for 1978: Prof. E.S. Rajagopal of the Indian Institute of Science, Bangalore (at present at the Australian National University in Canberra) and Prof. J.V. Narlikar of the Tata Institute of Fundamental Research, Bombay, share the prize for physical sciences.

The prize for chemical sciences has also been shared by two persons, Prof. G. Mehta of Hyderabad University, Hyderabad, and Prof. Girish Govil of the Tata Institute of Fundamental Research.

Dr. Viswanath Sasisekharan of the Institute of Science, Bangalore, receives the prize for biological sciences, while Mr. S.N. Seshadri of the Bhabha Atomic Research Centre, Bombay, and Prof. D.V. Singh of Roorkee University, Roorkee, share the prize for engineering sciences.

Prof. E.V. Krishnamurthy of the Institute of Science, Bangalore, receives the prize for mathematical sciences while the prize for earth sciences has been awarded jointly to Prof. B.L.K. Somayajulu of the Physical Research Laboratory, Ahmedabad, and to Prof. H.N. Siddiquie of the National Institute of Oceanography, Goa.

Winners for 1979: While no prize has been awarded for the chemical sciences for 1979, the prize for physical sciences has again been shared by two persons, Prof. S.S. Jha of the Tata Institute of Fundamental Research, Bombay, and Prof. A.K. Ghatak of the Indian Institute of Technology, New Delhi.

The prize for biological sciences has been awarded jointly to Dr. A.N. Bhaduri of Jadavpur University and to Dr. M.K. Chandrasekharan of the School of Biological Sciences, Madurai.

A joint award also for the mathematical sciences goes to Prof. S. Ramanan and to Prof. S. Raghavan, both of the Tata Institute of Fundamental Research. Prof. V.K. Gaur of Roorkee University, receives the prize for earth sciences. for earth sciences.

ICMR awards

While the CSIR has made no Bhatnagar award for the medical sciences, both for 1978 and 1979, the Indian Council of Medical Research (ICMR) has announced the names of twelve bio-medical scientists selected to receive the Council's national awards "for original and outstanding research contributions in their respective fields..."

The winners are Dr. M.G. Deo of the Cancer Research Centre, Bombay, for his work in experimental pathology; Dr. J.K. Sarkar of the School of Tropical Medicine, Calcutta, for his studies on arbovirus and smallpox; Dr. S.S. Kaplay of the National Institute of Nutrition, Hyderabad, for his work on protein malnutrition; Dr. P.N. Shah of the Cancer Research Institute, Bombay, for his studies on breast cancer; Dr. R.N. Chakravarti of the Post-graduate Institute of Medical Education and Research, Chandigarh, for his contributions to the study of atherosclerosis and thomobosis; Dr. H. Srinivasan of the Leprosy Training Institute, Chingleput, and Dr. G.P. Talwar of the All-India Institute of Medical Sciences (AIIMS), New Delhi, for their studies on reconstructive surgery in leprosy and immunology of leprosy respectively; and Dr. Satyawati Chandra of the Industrial Toxicology Research Centre, Lucknow, for her studies on manganese poisoning.

The ICMR's Shakuntala Amir Chand prize has been shared by four persons—Dr. Minati Das of the Indian Institute of Experimental Medicine, Calcutta, Dr. A.N. Malviya and Dr. N. Kochapillai, both of AIIMS, New Delhi, and Dr. H.V. Bhatt of the National Institute of Occupational Health, Ahmedabad. Their areas of study are neuropharmacology, clinical immunology, radiation biology and psychopharmacology, respectively.

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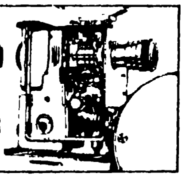

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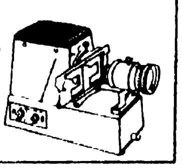

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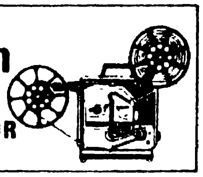

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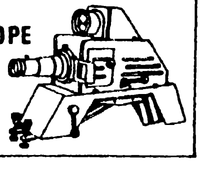

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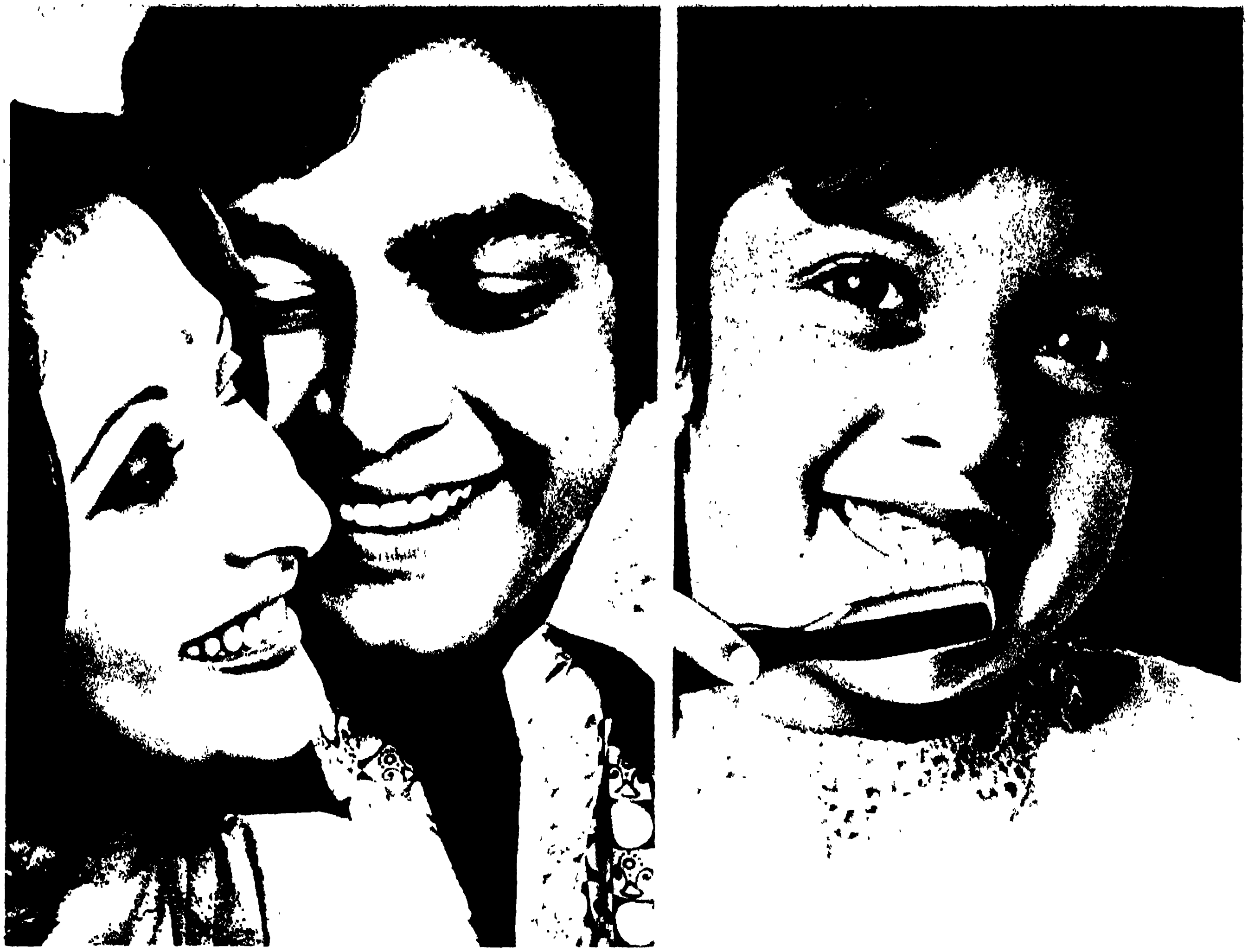

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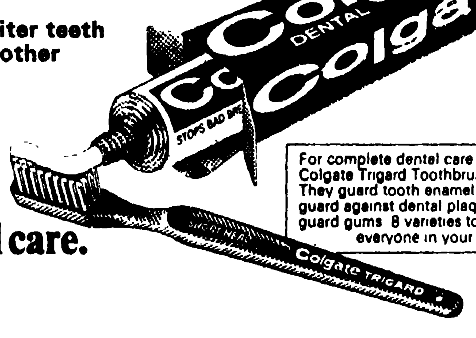

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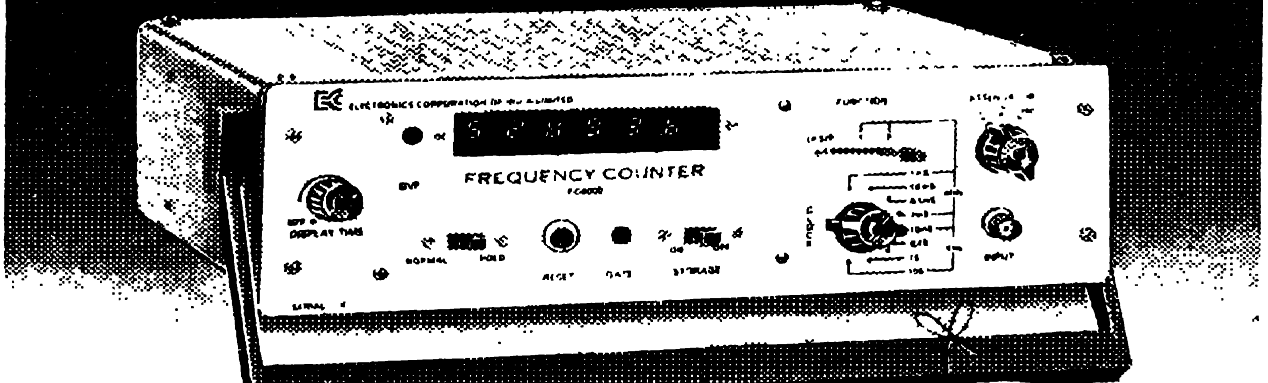

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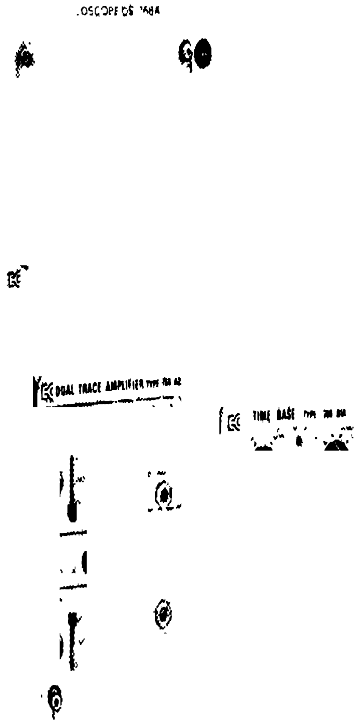

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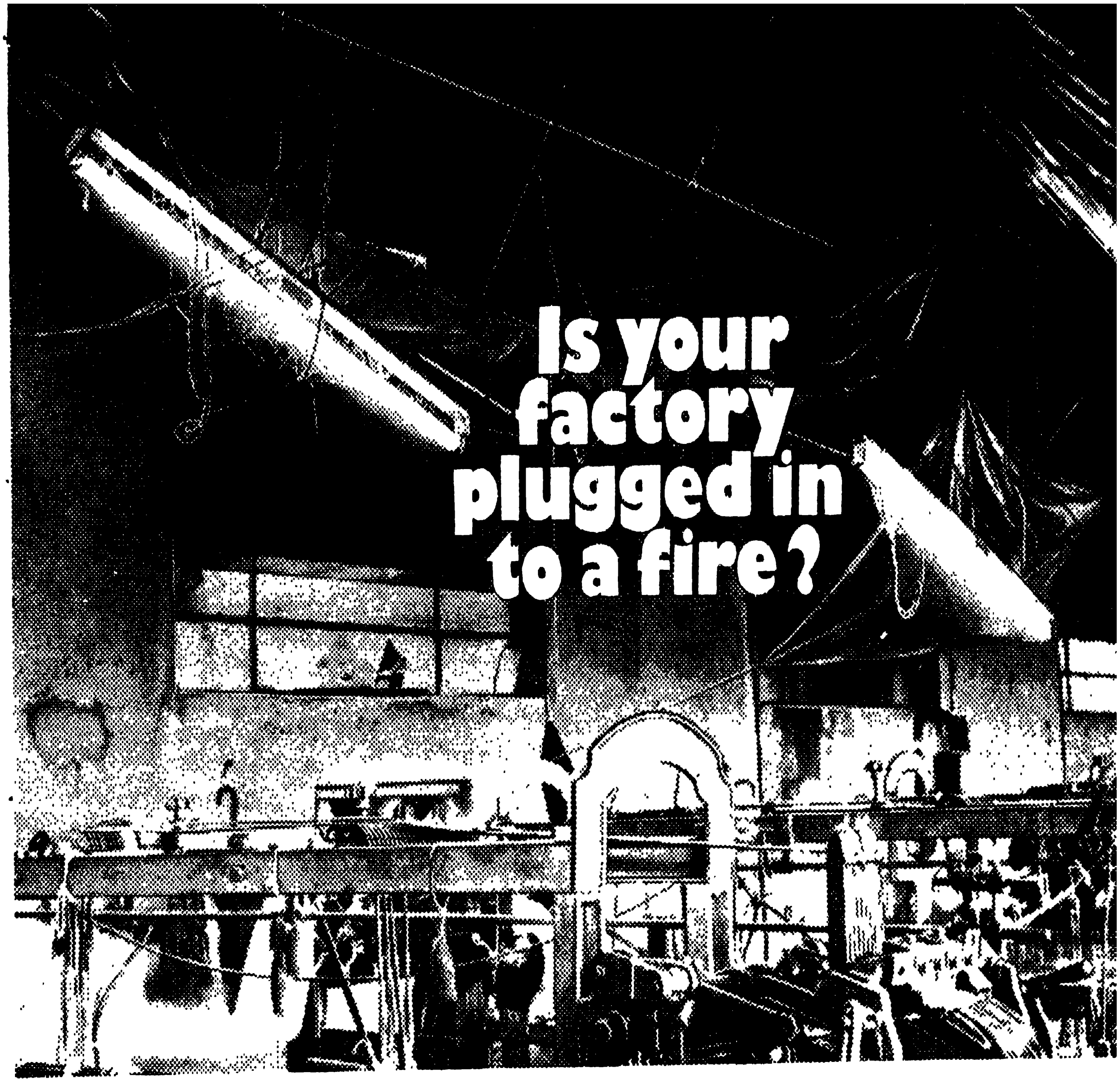

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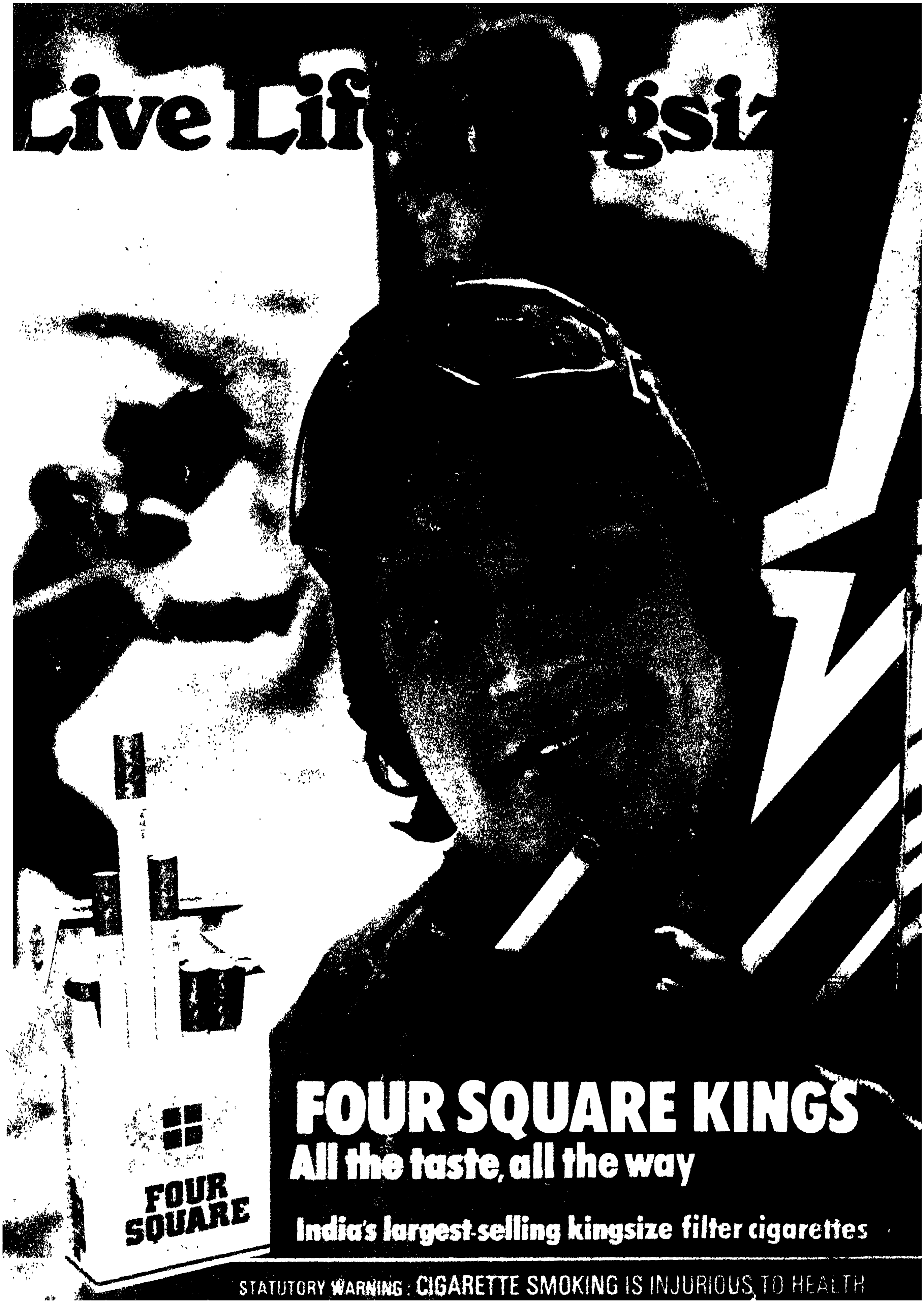
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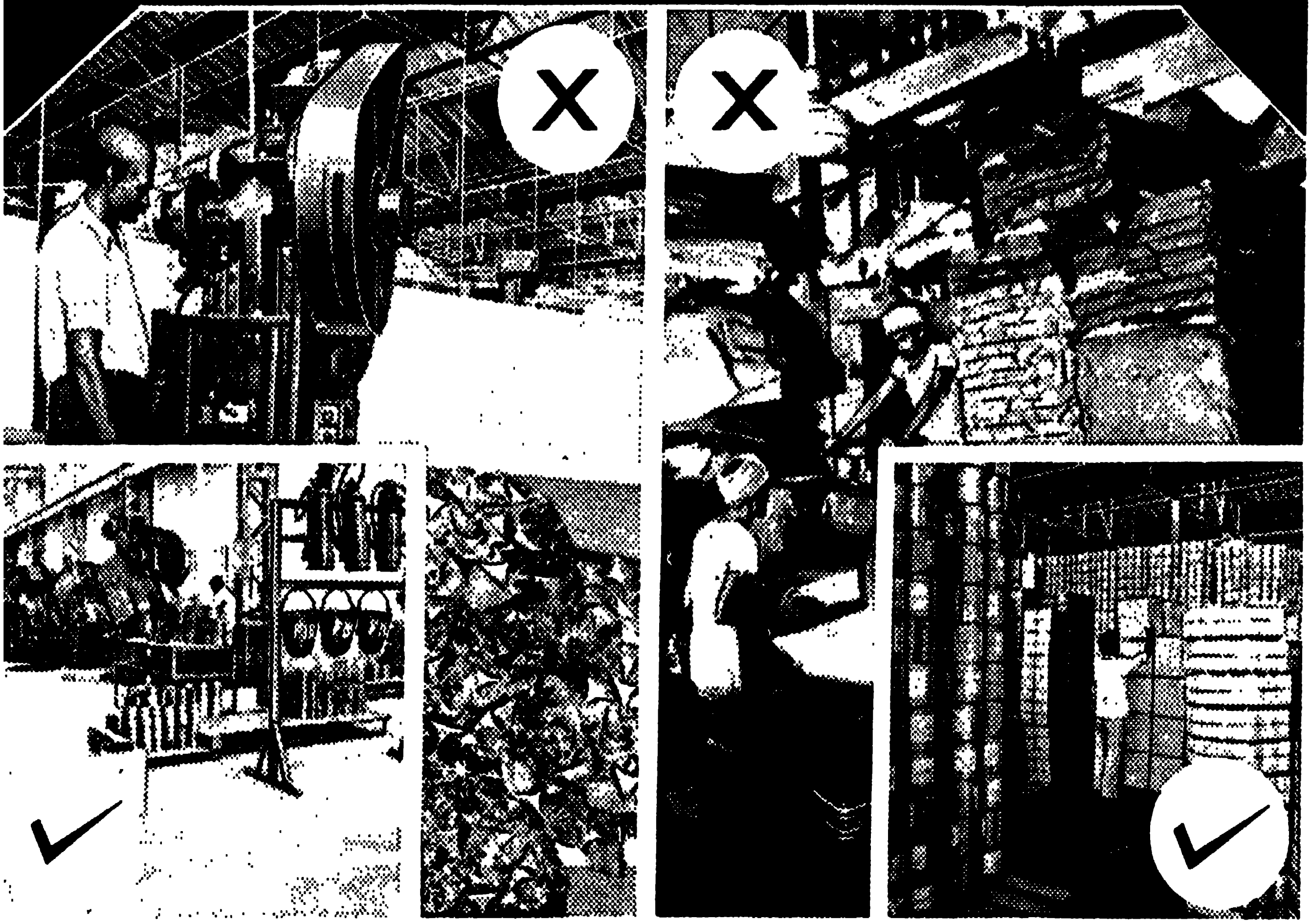

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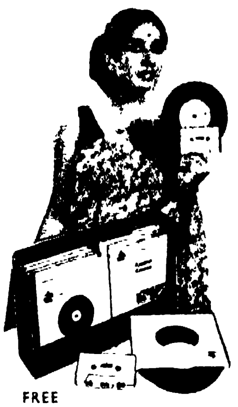

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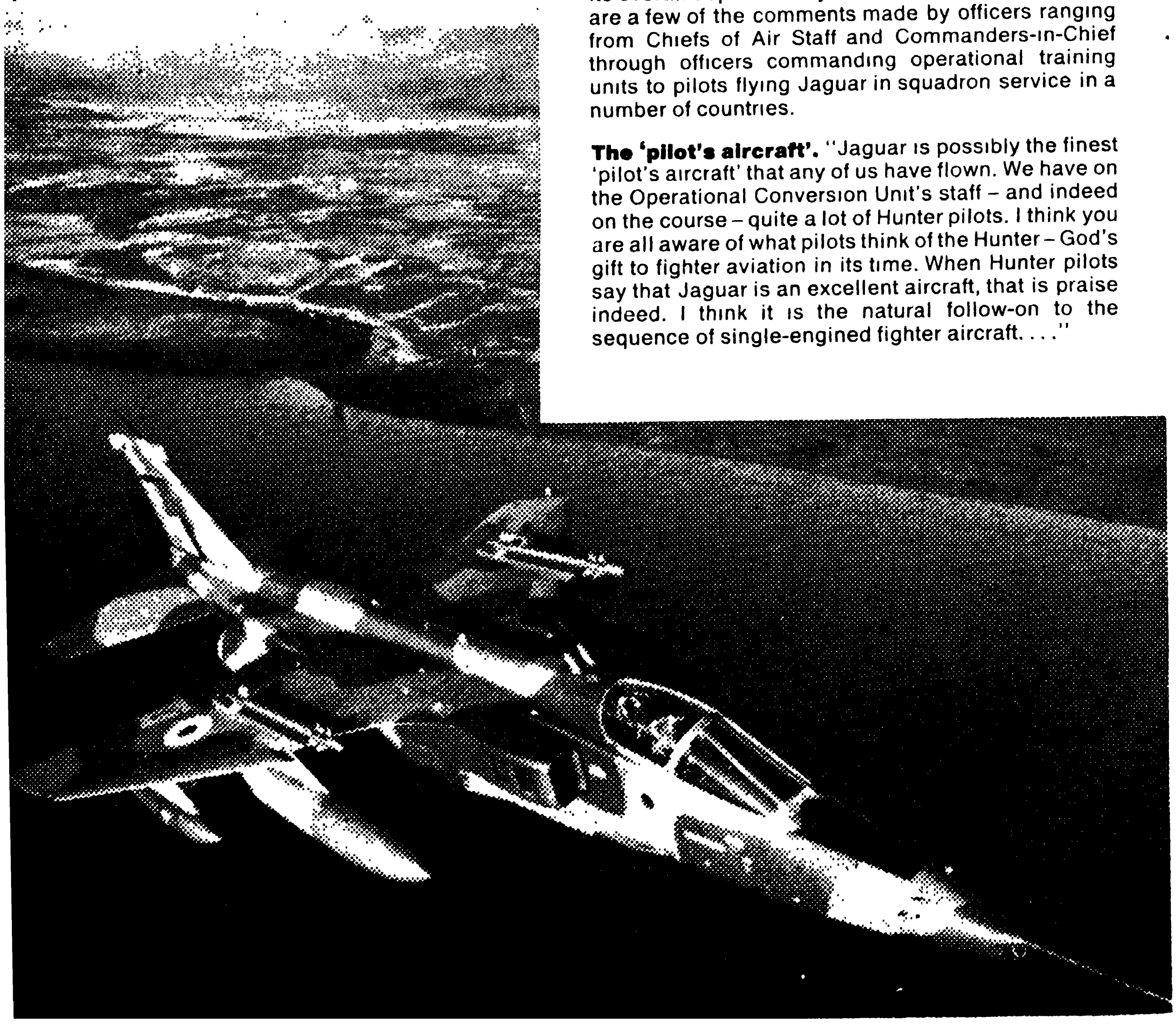

Work capacity. "I have never met anyone who was not agreeably surprised to discover Jaguar's marvellous performance, and the effortless way it helps a squadron do twice as much in half the time...."

Performance in the air. "Everyone – including myself, and I have flown the Jaguar – is delighted, its performance has come well up to expectations . . . not only in its performance in the air, but also on the ground . . ."

Low-level flying. "Jaguar has a long fatigue-life. It was laid down on the drawing-board from the start with the low-level environment in mind . . . being built for low-level, it handles beautifully at low level..."

Close-support capability. "Jaguar is a doggone good close-support aircraft; a good low-altitude, medium battle-support airplane, or a battlefield interdiction weapon; carries a lot of ordnance; highly manoeuvrable; good acceleration and performance down in the area where it was designed to fight, mainly in the low-altitude regions . . . I think it is a very, very fine bombing-platform and, since it is equipped with two 30mm guns, it is very effective against armour . . ."

Survivability. "It would take a very serious and lucky hit to take you completely out of fuel . . . Like the Americans found in Vietnam, I think operationally the twin-engined aircraft really comes into its own... The great survivability factor, we feel, is that for the first time, really, we have got an aircraft where you can virtually guarantee – on interdiction-type targets – making the very fast, low-level, straight-pass attack. This must surely be one of the big aids in keeping yourself in one piece..."

Combat effectiveness. "Jaguar is 20 times as effective as the 600 mph Venom of 25 years ago. The modern strike plane is equipped with electronic devices that make the destruction of targets 18 times more certain than was possible 25 years ago. We are now in the 'bomb-in-a-bucket' era..."

Rough-field performance. "About 1½ times the weight of a Hunter, Jaguar can land slower than a Hunter... It is quite capable of operating from typical flying club-type grass strips ... The brake parachute ... really does pull you up. With a lot of low-pressure rubber on the runway and high-energy-absorbing brakes, this aircraft can pull up very quickly indeed. The big low-pressure tyres and high-energy-absorbing undercarriage mean you can touch down on Jaguar without knowing you have touched. Nosewheel steering means you can use all the brakes in a cross-wind."

Cockpit layout. "The designers got the priorities right. Everything that matters is right in front of you... the pilots like the cockpit, it is a very, very good fighter cockpit."

Radius of action. "...the aircraft surprised everyone by its radius of action, which is almost double that of the present generation of aircraft and is increased still further by its capacity for flight refuelling . . ."

Accuracy of attack. "If you get your HUD pipper on the target, you can hardly fail to deliver your bombs within an effective radius... In fact, accuracies within 20 ft. are common..."

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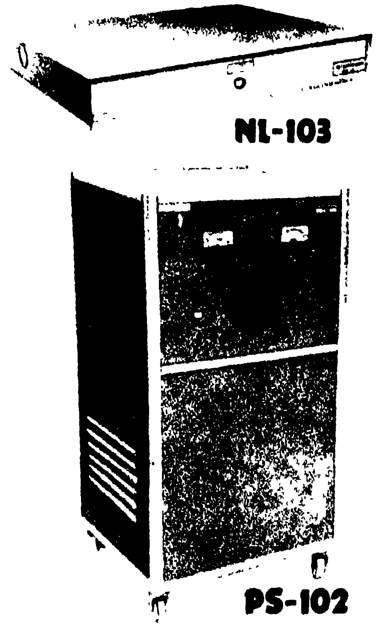

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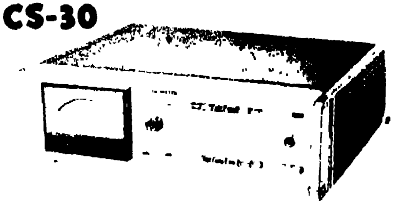

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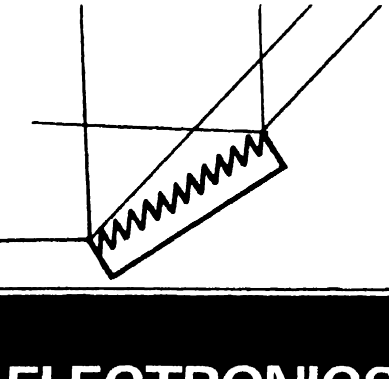

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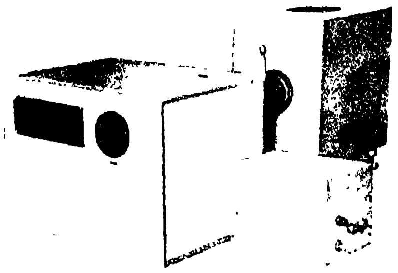

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Science Today

March 1980 Vol 14 No 3

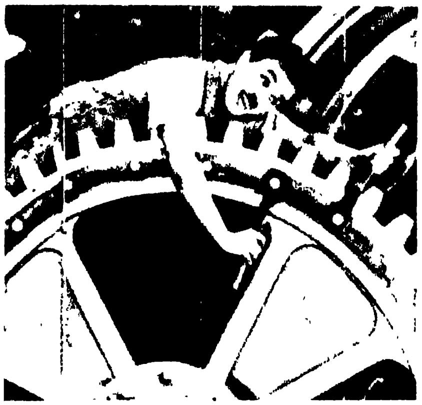
23 The evolution of behaviour
Madhav Gadgil
Sociobiologists explain all behaviour in terms of genes

28 Why we behave as we do
V. Nanjundiah
How much can we extrapolate from animal behaviour?

43 Towards a 'Grand Unification'
Virendra Singh
What started with Newton, Faraday and Maxwell continues with Glashow, Weinberg and Salam—the second part of the article

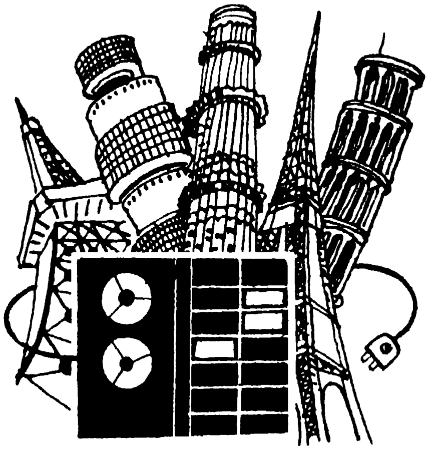
52 The scene of the crime
Pritam Phatnani
How forensic scientists assist the police in pinpointing the actual scene of a murder—some true case-histories

60 Limits to human performance
Krish Pennathur
We can twist knobs, pull levers, memorise or work out new ideas. Are there no limits to human performance?



64 The method of science-3
How a scientist generalises on the basis of his experiments.

67 Communications through computer networks
S. Ramani
Interlinked computers promise to banish distance as a barrier in communications



7 Letters
9 Viewpoints
15 View from New Delhi
17 Blurs and Bright Spots
19 Science Shapes Life
35 Round-up of Research
39 This World of Science!
39 In Lighter Moments
41 Ideas and Inventions
41 Brain Teasers
55 Fun with Mathematics
56 If..
57 Quiz
62 Tell Us...
71 Books
71 Awards and Appointments
72 You Too Can Do It

9 Will science survive in our older universities?
15 Stem this rot, now!
55 The law of first digits
56 If... a supernova occurred near our solar system
57 How much do you know about textiles?
62 Do water taps make good electrical earthing?
72 IC whistle-tuned remote control
74 The Bombay Mathematical Olympiad (Answers)

Cover: Nana Shivalkar

Editor:
Surendr Jha

Editorial queries are to be addressed to the Editor, SCIENCE TODAY, Times of India Building, Dr. D.N. Road, Bombay 400001. Unsolicited articles must carry adequate return postage.

Single copy Rs 2
Subscription 1 year Rs 20,
2 years Rs. 39; 3 years Rs. 58.

Subscription queries and payments should be addressed to the Circulation Manager, SCIENCE TODAY, Times of India Building, Dr D.N Road, Bombay 400001.

Printed and published for the proprietors, Bennett, Coleman & Co , Ltd , by T P Pithavala at Usha Offset Printers Pvt. Ltd., 125, Govt. Industrial Estate, Kandivli, Bombay 400 067 General Manager Dr Ram S Tarneja. Branches 7, Bahadurshah Zafar Marg, New Delhi 110 002; 139, Ashram Road, Ahmedabad 380 009; 105/7A, S.N. Banerjee Road, Calcutta 700 014. Offices at 13/1, Government Place East, Calcutta 700 069; 63, Montieth Road, Egmore, Madras 600 008; 407-1, Tirath Bhavan, Quarter-gate, Pune 411 002-26, Station Approach, Sudbury, Wembley, Middlesex, London, U.K. London Tel. 01-903-9696

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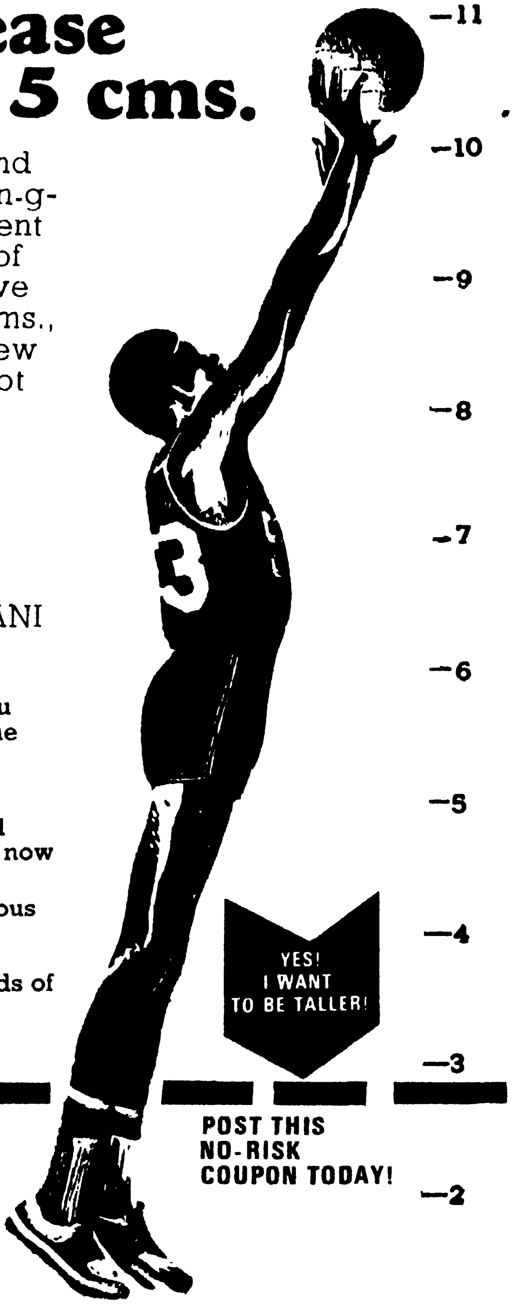

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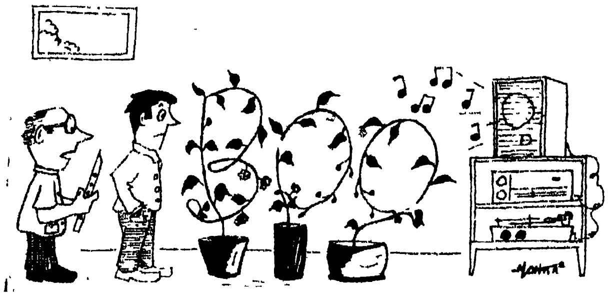
THE DANGER OF PSEUDO-SCIENCE

THE DANGERS that can come to science as a result of pseudo-science are well brought out in "The Not-So-Secret Life of Plants" (November 1979). The experiences in this regard at the Bose Institute and in the J.C. Bose Laboratory, which works on problems posed by J.C. Bose on the nature of plant responses, may be of interest.

Nowhere in his writings or communications had Bose stated that plants are capable of perceiving their environment like human beings or the higher animals. But it is strange that the very opposite views have been foisted on him.

In July 1976, the Bose Institute received a letter from the Regional Officer of the Central Board of Film Censors, Calcutta, asking permission to let a Mr. Walton Green film a part of *The Secret Life of Plants* at the Institute. The film script was also submitted to us. We give some excerpts from it, with our comments bracketed in italics.

"Along the banks *(of the Hoogly at Calcutta)* Vedic sadhus recite the hymn of creation in which all forces and all things are united into one... A horse-drawn carriage takes an elderly gentleman *(We wonder who this is.)*... to the strange Hindu-Victorian building *(sic)* of the Bose Research Institute. In the carriage, the man talks about his grandfather Jagadish Chandra Bose, founder of the Bose Institute and pioneer physicist. At the institute, using stills and film in combination with actual voice recordings of the elder Bose *(There is no known existing voice recording of Bose),* working among his strange machines built of teak *(Bose never made any instruments of teak)* and gleaming brass, Bose came to know the excitement of the revelation from the realm of plants... Bose found out what only mystics had suspected. Plants were sentient. .they could feel."



"Their response to music makes us rather uneasy"

Again, on 14 March 1978, a Mr. Marcel Vogel gave a lecture at the Bose Institute, claiming that he had influenced plant growth by meditation. He performed two experiments with Bose's instruments, both of which failed to support his claim.

Naturally, the Bose Institute could not agree to all these outright contradictions of facts. These only confuse the ignorant and denigrate our science and our scientists.

D. Sen
(Dept of Botany)
B. Mitra
(Dept of Physics)
Bose Institute
Calcutta 700 009

EQUATION FOR NEUTRAL CURRENT PROCESS

IN MY ARTICLE on the 1979 physics Nobel prize (Science Today, December 1979), there has been an error in the expression describing an example of a "neutral current" process (p. 63, bottom of second column). The reaction printed is an example of a "charged current" process. An example of a "neutral current" process would be

$$\nu_\mu - p \quad \nu_\mu$$

B.M. Udgaonkar
Theoretical Physics Group
TIFR, Bombay 400 005

DISTORTED AND MOTIVATED?

"WHAT IS happening at AIIMS?" (View from New Delhi, December 1979) was a distorted and motivated report although its author, Dr. K.S. Jayaraman, was shown documentary proof against what he says. The report was unanimously condemned at a recent faculty meeting here.

Take his statement that "only about 10 of the 270 faculty members are Dr. L.P. Aggarwal's followers. Some hundred are time-servers..." It is very difficult to believe that Dr. Jayaraman had interviewed about 270 faculty members here before writing that.

It is true that Dr. M M. Kapur filed a writ petition against the appointment of Dr. L.P. Aggarwal as the director of the institute. Dr. Jayaraman has deliberately tried to mislead the public by ignoring the fact that Dr. Kapur's writ petition was dismissed *in limine* by the High Court. The case is at present *sub judice* consequent to Dr. Kapur's appeal to the Supreme Court, and as such, we would not like to comment upon this.

Dr. Jayaraman, while mentioning that some persons working in the super-speciality fields here are thinking of quitting, does not name even a single individual. Besides this, he ignores the fact that the present director is the senior-most professor of the Institute and became dean and director on his merits alone. He was neither appointed by proxy nor by anyone's courtesy, as the author hints, and his appointment was made for a period of five years, irrespective of the age of the incumbent. Dr. Jayaraman contradicts himself when on the one hand he tries to make out that the government was reluctant to appoint Dr. Aggarwal as director, and on the other, charges the government with having done him a favour.

To say that Dr. Aggarwal has made important appointments of persons from his own alma mater (Lucknow Medical College) alone is false. Besides one or two such appointments, which were made on seniority alone or on the basis of expertise, others may be quoted: Dr. N.C. Nayak (from Orissa), professor of pathology, has been made officer-in-charge of the library; Prof. S. Bhargava (from Punjab), professor of radio diagnosis, has been appointed chairman of the Hospital Management Board; Dr. R.P. Sinha (from Bihar), associate professor of hospital administration has been appointed as member-secretary of the Hospital Management Board; Prof. L.N. Mohapatra (fron Orissa), professor of microbiology, has been appointed superintendent of hostels. These are only some examples.

As far as research is concerned, the Research Committee here has pointed out that research publications have increased after the new director's appointment. Research grants have been raised from Rs. 0.4 to Rs. 0.8 million and the money received from outside has increased from Rs. 0.62 to Rs. 0.68 million. The director has not restricted anyone's research activities. Research at the institute is flourishing. and the statement made by Dr. Jayaraman that "research has come to a standstill" is absolutely wrong.

G. Gopinath
Public Relations Officer
AIIMS, New Delhi

Dr. Jayaraman writes: Mr. Gopinath's long letter cannot disprove what will be obvious even to a casual visitor to the AIIMS. The faculty was and is alienated. I am sorry if the director has denied some of the statements I had attributed to him. But that is his prerogative. I stand by whatever I had said in my original report and would like to add that, in my view, institutions are more important than individuals.

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SIMOES/AG/6/79

Will science survive in our older universities?

In an article "Can we salvage Indian science?" (Science Today, February 1979, p.6), Prof. G.N. Ramachandran made an articulate defence of fundamental science. Its importance could hardly have been better emphasised. The article provoked me to highlight the problems of fostering good science in universities. What are the conditions in our universities? Are they conducive to the growth of science? We will take the case of Delhi University. For there have been some appalling trends, and what happens at a national university should be of concern to all.

Although Delhi is a young university compared to Bombay, Madras, Calcutta, or Allahabad, it shot into national eminence in the post-war years of independence, because of the direct interest taken by the Government and the able administration of Maurice Gwyer (India's last British Chief Justice). It was also the time when the famous science departments were built. Physics was headed by Prof. D.S. Kothari, who, despite his later jobs as the Defence Adviser to the Government of India and then as Chairman of the University Grants Commission (UGC), continued to live in the campus and take a deep interest in the teaching of physics and indeed the growth of the whole university. Prof. Kothari had gathered men like Majumdar, Kitchlu, A.R. Verma, two of whom later became, successively, the directors of the National Physical Laboratory. Gwyer also brought the late Prof. P. Maheshwari from Dacca University to head the botany department and Prof. Seshadri from Andhra University to head the chemistry department in 1949. A comparatively slow-starter, the zoology department finally became one of the best departments when Prof. B.R. Seshachar came from Bangalore to head it.

All these were men of great eminence. Fellows not only of our national academies of sciences, but even of several foreign academies. Prof. Seshadri and Prof. Maheshwari became Fellows of the Royal Society of England, and both became presidents of the Indian Science Congress. Even after Gwyer retired, the university had a succession of eminent educationists and academicians like S.N. Sen, G.S. Mahajani, V.K.R.V. Rao, N.K. Sidhanta, C.D. Deshmukh and B.N. Ganguli as vice-chancellors. And the tradition continues, with a reputed chemist and a former president of the Indian Science Congress being the last incumbent. One should also mention the Patel Chest Institute, set up under Delhi University and now headed by Prof. A.S. Paintal, another Fellow of the Royal Society (of Edinburgh) and a leading figure in medical research in India.

The changed scene

Yet, today in the university decadence has set in and a good many of the science departments are crumbling. Brighter students, say in my own field of biology, prefer to go to the molecular biology unit at the Tata Institute of Fundamental Research in Bombay or the Indian Institute of Science in Bangalore. And there seems to be no point in dissuading them. In the physics department, things have been administratively so bad that during the last few years no head has been able to complete his term, though in the present system one gets a straight term of three years. Resignations have been galore with consequent confusion and instability. With a staff of well over 60 teachers, who now form a "Staff Council", no head quite knows how to deal with them. Indeed, the council has a "speaker" who is not the head and in staff meetings one witnesses amusing confrontations.

The older physics and chemistry departments admit as many as 150 to 200 students each, but only a fraction turns up for research or even utilises the training. Even as Ph D students draw scholarships, many clandestinely prepare for competitive examinations such as the IAS and the State Bank of India service. Administratively, the chemistry department has perhaps fared a little better; even so, students have been leaving. Some bright ones choose to go abroad or to the Jawaharlal Nehru University (JNU) or join other institutions. They think the department has been following rather narrow lines of research. Chemistry has seen several new developments—the rise of photochemistry, biochemistry, and the chemistry of proteins and nucleic acids. The gene has been synthesised and the genetic code has been discovered. Advances have been made in stereochemistry, synthetic organic chemistry of complex natural compounds, the use of computers, fast reaction kinetics, polymer and silicon chemistry, etc. But these developments seem to have largely bypassed India's foremost university. And strangely, the famous chemistry department functions without a satisfactory mass spectrometer, without a functioning gas chromatograph, without modern radioactivity measuring instruments, fraction collectors or other modern aids such as the optical rotatory dispersion analyser!

In the zoology department, M.R.N. Prasad has left, though K.N. Saxena and Sunder Raj (the new head) continue, trying to keep the tempo. But there is no denying that after the mid-sixties (when all the founders had nearly gone) things are not the same. Not certainly in the botany department, where I teach.

Why this state of affairs?

Why should people be reluctant to continue in a university which, in a sense, used to and should occupy in our country the position of Harvard in the USA or Cambridge in England. Why is the JNU, or even the far off Madurai University, preferred to Delhi? During my own chairmanship, I tried to prevent some people from leaving, but unsuccessfully. Nor did I succeed very much in bringing people from other universities even on promotions.

Several are the reasons for this deterioration. The most important perhaps is the unprecedented and unexpected expansion in the number of students. In 20 years, the university increased its enrolment from about 20,000 in the 1950s to more than 100,000 today. The number of faculty members rose from some hundreds to the strength of about 5,000 now. Students came in like a flood; everybody who had passed the higher secondary had to be admitted. Colleges multiplied from about 10 (in the fifties) to 55 today. Standards had to be cast aside. In most good universities like Harvard, Yale or the Massachusetts Institute of Technology, the BA or the B Sc degree is very much a part of teaching of university departments but here almost overnight the B Sc programme, including even the honours, was relegated to the colleges (the college teachers were, of course, keen because it opened avenues for promotions). Many colleges of nondescript character and names sprang up. Nowhere in the history of the scores of older institutions which have survived—Göttingen, Tübingen, Harvard, Caltech, etc—has there been such a mad, unplanned growth.

The vast number of students caused, in no time, an administrative problem of a magnitude which now

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seems to defy all ingenuity and solution. The constitution of the university being what it is (all colleges are constituent colleges and opinion is against autonomy because every college wants to identify itself with "Delhi University"), all problems finally converge on to the vice-chancellor. The general direction of changes in statutes or ordinances is such that the final appeal rests invariably with one man, the vice-chancellor. Not only does a teacher's suspension or dismissal go to him, but matters also of attendants and bearers in remote colleges, or of scuffles between bus conductors and students which are quite frequent. No wonder, Dr. K.N. Raj, a vice-chancellor, who left in disgust after only a year in office, said that a vice-chancellor at Delhi University could do little else than attend to small firefighting operations.

The growth of unions

The greatest complicating factor has perhaps been the rise since the mid-sixties in the activity of various pressure groups and unions, mainly the Delhi University Teachers Association (DUTA), Delhi University Appointed Teachers Association (DUATA), Delhi University Students Union (DUSU), Delhi University Research Scholars' Association (DURSA), and the most important, Delhi University and College Karmachari Union (DUCKA), each having its own axe to grind. The vice-chancellor has to be continually alert to all these organisations. And I am afraid both the academic and executive councils of the university have become virtually powerless, if not useless. The former body is too large (more than 100 members, including now many 'elected' teachers); wryly, some think this is one body where no academic discussions can take place. We have a new, aggressively verbalist generation, and now the verbalist exercises more than the due share of influence compared to the physicist, computer engineer or the chemist whose vocation is more concerned with abstract thinking, design or chemical reaction, rather than with words. Even the executive council is getting politicised. Thus the general atmosphere of the university is affecting not only research in all science departments (where normal supply of water and electricity is a must), but even ordinary teaching.

Maybe, my remarks about the unions are somewhat unkind and will arouse needless indignation. Organisations such as the unions can play a vital role when authorities or powerful individuals turn treacherous. But, unfortunately, it is usually the wrong people who make bold to seek their help, get to newspapers or other publicity forums. Others, perhaps more serious persons, usually resign themselves to their fate in quiet dignity. In fact, eminent people seem to have shied away from these organisations.

Rotation of headships

It is this general tide of democracy, and of imagined and real grievances that brought rotation of headships (college principals have been so far spared.) Gone seem the days when leadership in a department was academic or when leading men with progressive ideas selected by selection committees, on their merit, administered and developed the departments.

In India, as is the case in so many other spheres, the American or other western methods in education are adopted without understanding their full implications under local conditions. For example, we have adopted some points of rotation but not others. In the US, a rotating chairman has hardly any powers. His main job is basically routine administration, like signing appointment letters or fellowship forms on behalf of the board of trustees or other committees, arranging for library, xerox and other services, allocating space and arranging general seminars. Recognising the fact that the rotating chairman need not be the most eminent academician, at Harvard or elsewhere, if an appointment has to be made, the Search Committee must include all senior professors in an area. In fact, a body of professors recommends appointments. But, in Delhi University, senior professors (whom the university has not declared incompetent or insane in any way) are debarred from any selection process except for a brief period when they might be chairmen. Let us also remember that in India positions are not brought or created by the university itself. In our socialist style system, both the five-year plans and the UGC are important and it is only by random chance that a particular chairman may have the right to decide on the positions. And this gives him power which is, sometimes, completely out of proportion. In some universities, chairmanship can pass on even to readers, as, for example, in Rajasthan and Delhi.

All this can be and should be contrasted with systems such as in the Max Planck Institutes of Germany where a department is under the undisputed direction of a well-known professor. In fact, the department is built and named after him. And as for the bigger US institutions, the whole comparison is misleading — a professor's group is generally a department, at least in terms of physical facilities. Fortunately, national grant-giving agencies in India, like the Council of Scientific and Industrial Research, the Indian Council of Agricultural Research and, lately, the UGC and the Department of Science and Technology have come into existence. But even an average handsome grant rarely exceeds Rs. 2 to 3 lakhs for a four-year period. While it does pay for the salaries of a couple of research fellows and technicians and provide for contingencies as well, equipment like spectrophotometers, ultracentrifuges or a gas chromatograph are, as a rule, quite out of reach of an individual grantee. It is the prerogative of the head of a department to build up major facilities and this is where we need competent men with vision who can see beyond their little areas of specialisation and of even educating others.

Staff councils

The wave of "democratisation" has also brought in staff councils. Perhaps this is alright for general consultations or policy decisions. But the current mode of functioning of staff councils has glaring absurdities—a member who joins yesterday has the same vote as a professor or reader on all matters. When it comes to decisions on space, recurring grant, or nonrecurring equipment grant, pressure is on for decisions to be taken on a per capita (teacher) basis regardless of the student number per teacher or the nature or demand of research. Indeed, in my department, it was a miracle when I could get a majority to support an equipment programme for biochemical instrumentation. As in most botany departments, people are trained in the method of the microscope and observation of sectioned, and generally dead, material. The majority have not used machines like spectrophotometers, scintillation counters, etc and it made no sense to them to waste precious money. Staff councils, as the situation obtains in India, are thus also a hindrance to progress.

Similarly, established old courses are hard to change. Measures to tighten up standards for admission turn on deaf ears because almost everyone is obsessed with promotions and gripped with the anxiety to put out a research paper of whatever quality, for which students readily provide cheap labour. It may sound incredible, but I have known fairly senior teachers, including full professors, arguing for taking in third class candidates!

With the morality prevailing in general social life, can staff councils deliver the goods? During my chairmanship, I generally managed to per-

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suade a good many to change from old courses to new ones as well as to adopt a new equipment acquisition programme. But with several unfilled positions which serve as a bait, a majority of the same teachers changed their views with change of chairmanship. And some of those unable to do very much then have now engaged in a tirade of baseless newspaper allegations. One is reminded of the current political scene in India—defections from the Congress to the Janata, from the Janata to the Lok Dal to the CFD and back!

Remedies

The foregoing is more a description of the current scene of political and scientific climate in a well-known university—some may think this is a sweeping indictment, but there are some harsh truths. The question now is how we can use the vast manpower (though admittedly resources are inadequate) more purposefully. Or, can science in Delhi University be brought back to excellence? Perhaps I can ponder knowledgeably about biology. In recent years, this area has been internationally at the forefront of all natural sciences. Cell and protoplast culture are emerging as new techniques of genetic manipulation. Recombinant DNA is being used to introduce chosen genes in living organisms with great potential not only in medicine but also in agriculture and forestry. Fundamental advances are being made in photobiology, including photosynthesis, biochemistry of development, regulation of gene activity and neurobiology—all of which are frontline problems. But where do we stand?

There is little of the frontline work being done here despite all the "prestige" associated with the university. To use Arunachalam's interesting phrase, we, too, cannot be absolved of the "pathological indifference to quality" ("Why is Indian science mediocre?" SCIENCE TODAY, October 1979, p.11). The departments here are now a kind of machine to turn out PhDs, irrespective of the quality—indeed, in some departments the main goal is to produce a PhD and get the recipient fitted in a college. The large numbers (in my own, there are about 80, though proper facilities for modern work do not exist for even half that number) have made sophisticated science impossible, and in a vast sea of mediocrity, I wonder how good science can survive. Perhaps, the Patel Chest Institute alone retains a somewhat different character but there, of course, they retain a different administrative set-up.

Speaking of remedies, I see I am in murky waters, particularly when problems have bedevilled and defied even a scientist vice-chancellor whose general competence and shrewdness have been recognised by all. Immediately, one can suggest remodelling and creating new, smaller departments. The big monolithic departments need to be split into small, homogeneous, more cohesive working teams and, in any event, insulating the departments from unnecessary bickerings, polarisation, and battles at cross-purposes. For example, the requirements and approach of general botany, say teaching and research in anatomy or systematics (I am not doubting their utility), have hardly anything in common with those of molecular aspects which need altogether different instrumentation and training methods. Why not let both grow without hindrance to each other? The same could be done in other departments.

This will also be an antidote to the ills of rotation where chairmanship must pass inevitably to junior men whose ideas may be (and are sometimes) refreshingly better, but maybe devastating as well. How often can you have a new chairman (in the new democracy) bold enough to reprimand a younger colleague for wasting time on writing a cheap textbook or in turning out a PhD in record time with unreliable data, or publishing papers in sub-standard journals. How, if ever, will a younger chairman contain the problem of bursting student numbers, which have made good science an utter impossibility (surprising as it may seem, even at Delhi, many have not heard of Eugene Garfield or his impact points)?

A second solution is that the UGC and the university administration should now look to the requirements of individual scientists rather than dole out grants to the whole department. The concept of pooled instruments under a department head is nonsense, particularly when one may neither have any knowledge of nor any use for a particular instrument. (Recently one department had the ghastly experience of a new head dismantling a cold room, costing Rs. 50,000, for biochemical work, assembled after 10 years just because he wanted an easier, short-cut passage from his room, to the head's room where he commutes!) The point is that the UGC should allow groups of teachers to be given their major equipments and such grants should be treated on a different footing from the usual "research fellow-cum-contingency" grants.

The most important reform needed perhaps is a return to academics and the old ways. Why should the unions often protect inefficient employees? Also, why dual representations in a council to a department or a college? I do not think it helps matters or the dignity of the councils to have another teacher (elected) engaging in verbal duels with his principal or head in public meetings. The real issue often gets side-tracked. Remedies lie in representations to higher authorities, not in fulsome bawdy debates. People do not realise that democracy can be carried to extreme chaotic limits. After all, if you elect a government, the government then appoints a vice-chancellor in consultation with the university and he, in turn, appoints heads and principals—that, too, is democracy. And, remove the vice-chancellor or head if he is not good enough.

I suppose this university (or others) cannot survive without a strong government at the centre. For, every flicker in New Delhi's top echelons affects work in individual laboratories. Although my remark should not be taken to mean that I support all the excesses and ills of the emergency period, it was only during this time that universities and departments functioned normally in recent memory. Having been educated at western institutions in younger days, many of us were champions of the Anglo-American style of democracy. But many of us have begun to wonder whether some other form of government, capable of acting strongly, resolutely and even unpleasantly sometimes, might not be better. Otherwise, I would think the bigger universities are so politicised that they may be written off, and it may be time to move back to the smaller ones. This might sound a cry akin to those of the environmentalists—"back to the villages or the smaller towns". There is perhaps some good sense in the movement—because at least one can breathe fresh air and enjoy the blue skies in idyllic surroundings which have become a rarity at least in this sprawling city campus with diesel buses emitting fumes, rattling the windows of homes, and every other day a slogan march of some union or the other rending the university air, destroying the calm and peace so basic for creative thinking.

S.C. MAHESHWARI

Prof. Maheshwari has been teaching in the department of botany at Delhi University for 25 years now. He has also worked at the universities of Yale, Oxford and Harvard and at the California Institute of Technology. He is a Fellow of the Indian Academy of Sciences, Indian National Academy of Sciences and also of the Indian National Science Academy. He was awarded the Shanti Swarup Bhatnagar Prize along with Prof B.B. Biswas of the Bose Research Institute, Calcutta, in biological sciences. His major interests are in the molecular control of development.

WHERE THE PIONEERS HAVE LEFT

The key nature of alchemists' role in laying the foundations of modern science, may be judged from only a partial list of basic scientific tools, associated with their names.

Chemistry had its origin in the laboratories of the alchemists. Alchemy eventually expired under the impact of science, but its tools and procedures were taken over by scientists in the modern world, to utilize it for extension of basic discoveries still further and bringing it closer to common man.

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Stem this rot, now!

THE United States recently put an embargo on the sale of high-frequency transistors to India. This put our defence department in a jam because it needs the transistors for its communication network. Eventually, India had to hire a foreign firm and pay Rs.450 million to set up the electronics surveillance system on its borders because its own electronics technology lacks sophistication. Nuclear energy is vital for India's power development. But its nuclear programme is off the track, being dependent on foreign supplies of fuel and raw material like heavy water.

Despite the Rs.5,000 million annual budget for science, a technical manpower which is the third largest in the world, and well-equipped research laboratories, self-reliance in science and technology in vital areas of defence and security remains a dream. The Vienna meeting on science and technology, and the UNIDO and the International Atomic Energy Agency Conference held recently in New Delhi made it amply clear that the rich nations are unlikely to end their technological imperialism. And to catch up with the West calls for renewed national efforts in the field of science and technology.

This doesn't mean we should build new facilities or pump more money into research and development. That will not help. Right now, the morale of the Indian scientific community as a whole is very low. What we, therefore, need are measures to boost this sagging morale. One hopes the new government will do something soon to improve the working conditions of scientists.

Take, for instance, the Department of Atomic Energy (DAE) which employs over 10,000 scientists and engineers. It used to be cited as a model scientific organisation. This ended with the death of Dr. Vikram Sarabhai. The Bhabha Atomic Research Centre Officers' Association (BARCOA) now alleges that the BARC scientists are "demoralised, alienated and pessimistic about their future". It says that a majority of the BARC's scientific leadership "has succumbed to the lure of administrative power and position, faltered in its vision, lost sight of the goals of the department and contributed to increasing alienation and frustration of the working scientists by a behaviour bordering on authoritarian, lawless, arbitrary, cynical and plainly unscientific". BARCOA says that the DAE has failed to exploit the talents of its scientists, and this is due to the "environment of insecurity in which the scientists have been deprived of effective academic freedom and have to work in a state of constant fear of arbitrary authority". The association has called for a thorough review of the DAE.

The Electronics Commission, another crucial organisation, is in no better state. The Sondhi (Mantosh Sondhi, secretary, steel and mines) Committee's recent recommendation to abolish the Commission has shaken people working in the Commission. The Commission's officials also resent the Committee's call for unlimited import of technology and foreign collaboration.

The Indian Space Research Organisation (ISRO) is not without problems. A top ISRO communications expert, who is next in rank to the chairman, had to fight in court to get himself reinstated after dismissal. He won the case but is still to be taken back by ISRO. ISRO's performance since Aryabhata has been on the downhill.

The Council of Scientific and Industrial Research (CSIR) and its 30 laboratories have become "static" under a part-time director-general. Its reorganisation, two years ago, attaching some of its units to "user" ministries, hasn't contributed to its efficiency. At least one director says the reorganisation has made scientists answerable to section officers in ministries.

But it is the Indian Council of Agricultural Research (ICAR) which is at its worst. About 70 scientists are fighting their cases against the ICAR in different courts. Some, like Dr. K. Swaminathan, of the Grassland Research Institute in Jhansi, who have no money to fight their cases, are fretting and fuming.

Dr. Swaminathan, a brilliant soil chemist in the S-3 grade was demoted to S-2, and made to work on seeds development, where he is a misfit. For three successive seasons, crops on his experimental plot in the institute were either set on fire or grazed out—deliberate acts, he says, intended to prevent him from publishing papers. While his appeals to the ICAR chairman have gone unheeded, a CBI investigation has been launched against him.

Prof. P.K. Ramachandra Iyer, a pathologist of repute at the Indian Veterinary Research Institute in Izatnagar, has been victimised for challenging the research claims of his director. His case is now in the Supreme Court.

Some 32 of the 44 scientists of the Central Tuber Crops Research Institute in Trivandrum recently trooped to the ICAR headquarters in Delhi demanding action against their director. The result was that three of their leaders were given transfer orders.

Such examples can be multiplied. The "temples" of science are corroding from inside while maintaining a neat facade outside. The primary job before the new government is to create a climate free of bureaucracy and authoritarianism in the scientific agencies so that working scientists can give their best.

How did this state come about in our scientific organisations? The pollution of the scientific climate is the result of centralisation of power in the hands of a few "eminent" scientists. Look at the enormous powers vested in the ICAR director-general; not only does he rule over the fates of 40 research institutes but he has the final word on the appointment of vice-chancellors of 50 agricultural universities. The DAE is an empire by itself, controlled virtually by one man. The situation where the entire spectrum of scientific research in the country is run by a handful of persons has not been conducive to the blooming of a thousand flowers.

Meanwhile the experiment of appointing scientists as secretaries in ministries has turned out to be a failure. Unrest has been mounting among scientists since the experiment began. The best way to reward a scientist of eminence is to leave him alone to pursue his discipline. To make him a secretary is not only to lose him for science but also to create an impression among other scientists that research is not an end in itself but a stepping stone to secretaryship at the Centre or a UNO assignment.

The absence of an outlet to vent grievances and get them redressed is the major cause of mounting frustration among scientists. The courts do not entertain writs from scientists of the ICAR and the CSIR which are registered societies. In the West, a scientist can quit one institute and join another the same day, but in India, where the scientific world is governed by feudal lords, such mobility just doesn't exist. This, coupled with the lack of an outlet for grievances, is turning many scientists into rotting vegetables. It would be sad if the rot is not stemmed now.

K.S. JAYARAMAN

Dr. Jayaraman is Science Correspondent of the Press Trust of India, New Delhi

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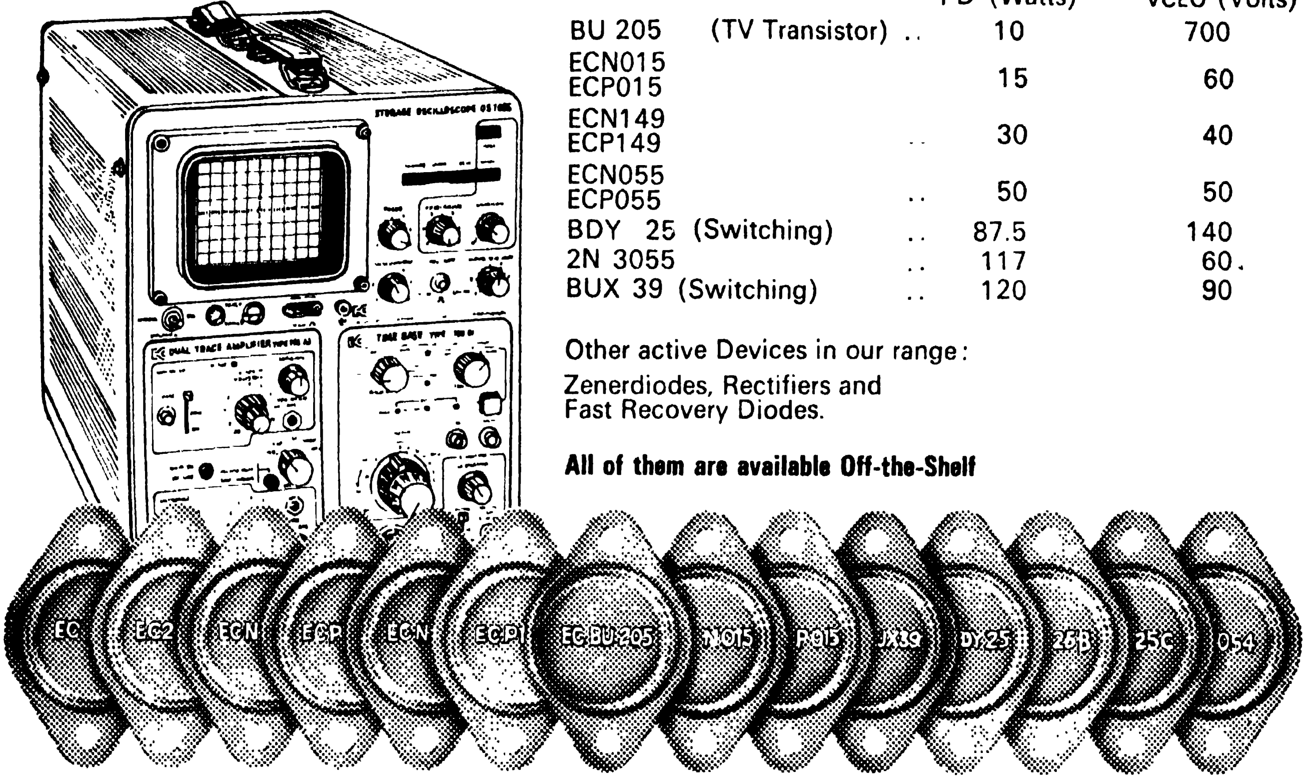

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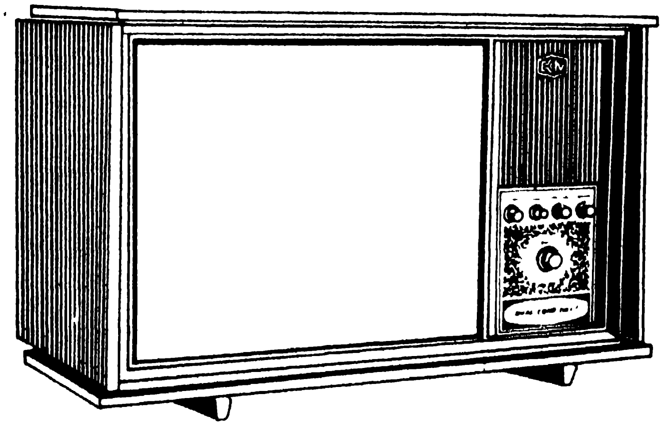

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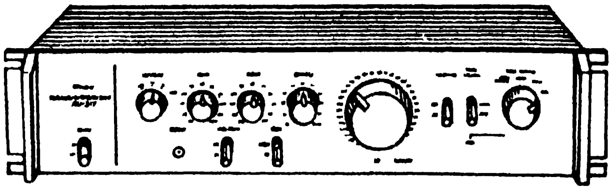

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The eclipse of reason

THERE ARE apparently two types of people: those who dread an eclipse and those who don't. Last month, those of the first category locked themselves up securely indoors and missed a wonderful natural event. Unfortunately, they formed the majority. And of those from the minority second group, many travelled hundreds of miles just to see the total eclipse. On 16 February 1980 I found myself with a group of amateur astronomers from Bombay, up on a hill in Ankola, Karwar, which was in the path of totality of the eclipse.

The 70 odd amateur astronomers formed a heterogeneous group, with a good number of scientists among them. With the hilltop littered with all kinds of gadgets, the amateur astronomers had usurped all the vantage points. A lot of experiments to study the eclipse and its effects had been planned. Within the cordoned-off area everything seemed to work with clockwork precision.

Seeing the large group on top of the hill, local villagers and students also flocked to the place. The fishermen who had helped to carry our heavy equipment stayed back and often borrowed our welder's glasses to see the eclipsed sun. One of them, observing a sunspot, asked what it was. As the eclipse progressed, the temperature fell, the breeze picked up and the vultures that had been circling in the region were no longer seen. Moments before totality a horde of snaky shadow bands raced past us and were clearly seen on the bedsheet we had spread on the ground. In the dimmed light this gave a creepy sensation—as if we were amidst snakes. These shadow bands are probably behind the well-known "snake-devouring-the-sun" myth.

The huge corona lit up the sky and so the midnight in the afternoon we had been waiting for failed to materialise. The atmosphere seemed eerie as in a Hitchcock film with faces looking waxy and bluish and the colours of clothes changing as if we were under an extremely powerful mercury vapour lamp.

When the magic moments were over, we noticed two journalists from a Malayalam magazine, *Kala Kaumudi* of Trivandrum, conducting an experiment unknown to the amateur astronomers. They walked around with a packet of biscuits, offering it to scientists in the group. Their experiment resulted in a surprising observation. Many scientists they approached, although without proper food for long that day, refused to eat the biscuits. A good number of amateur astronomers too, it turned out, had abstained from food and drink that day. Was it a hangover of the penance that early men undertook to retrieve the sun from the grasp of the mythical snake?

One Hyderabad scientist did not see the eclipse considering it unlucky because his birthday fell on the same day. An Air-India engineer in Bombay had the same problem. It was his birthday too, and his thoughtful parents had sent him a contraption to wear on his head to ward off the ill-effects of the astronomical conjunction. Torn between fear and curiosity, this young engineer took off the head gear every time he felt like seeing the eclipse, replacing it after every furtive glance and trembled lest anything should happen. Another person, a Bombay University science professor and author of several books and papers whom we spoke to said it was wrong to eat during an eclipse, since "something bad was happening to the life giver, the sun." "You don't eat if your wife is ill. It is just like that," he explained, adding that there were harmful rays that polluted food and drink. So sure was he of himself, he did not mind being quoted. Other scientists explained they were only following rituals taught by the parents during their childhood and besides, they added, weren't rituals fun? Others did not like it to be known that they had fasted and still others said they were doing so because they had an 'open mind' since no one had found out what happened to the food stored during an eclipse. In several scientific institutes in Bombay including the prestigious Tata Institute of Fundamental Research, we were told, many scientists refused to watch the eclipse because they were not sure that the superstitions were baseless.

Why blame the laymen if scientists themselves are like this? It's no wonder that the confused reports by the media scared them all the more. Stories about people losing their sight and succumbing to heart-attacks or paralysis during the eclipse were common. Newspapers quoted gynaecologists warning pregnant women to keep away from sunlight during the eclipse because of "gamma rays"! Millions of people had seen an eclipse before and nothing had happened to them. However, none cared to emphasise this fact. The scare-mongering was a total success because of the confusion caused by contradictory reports. For example, some said it was dangerous to see the sun with naked eyes and one should use a protective filter. This of course was true. But, as to the filters, many different types were advocated—welder's glass, metallised plastic, smoked glass, a three-layer sandwich of completely exposed photographic film, etc—and for every *do* there was invariably a distinct *don't* from another quarter. As a result, the few who ventured out into the deserted streets were thought to be crazy. Indeed madness was, reportedly, one of the possible results of "eclipse exposure".

One 'astrotantrik', who claims to have correctly predicted world events, proclaimed that India would have 14 years of bad luck. Bloodshed and natural calamities like floods, drought, earthquakes, volcanic eruptions, political unrest (as if this is new) would ensue, he warned. A leading newspaper quoted him giving a double-column headline that summed up his predictions.

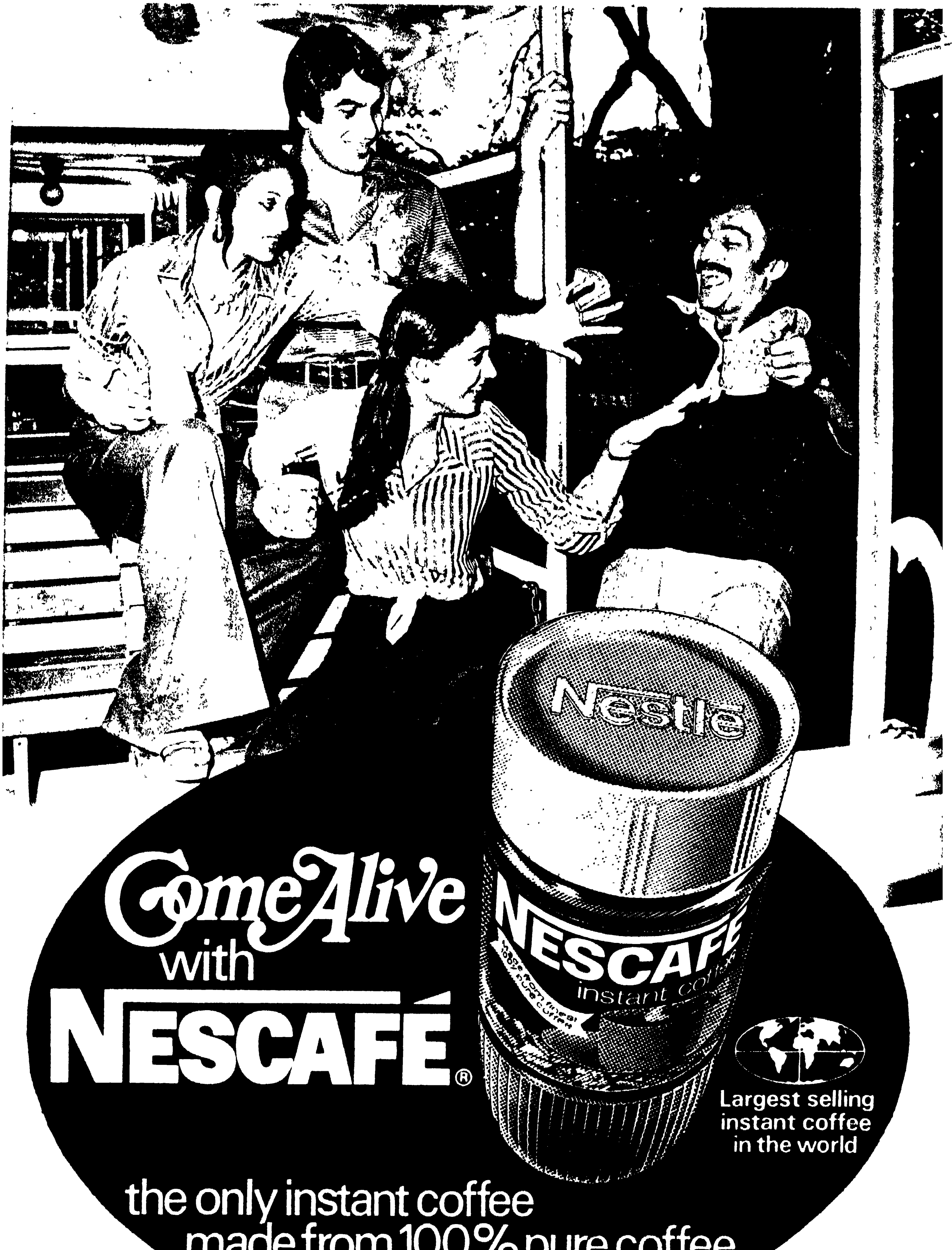
One astrologer, who claims to have cor- eclipse over India 82 years ago. The Railways had arranged special trains to take people to and from Jeur in Maharashtra that lay in the path of totality. And all the passenger coaches being full, people had to take goods trains or find other means. With the much higher education levels and better transport facilities today, some of us had in fact expected a traffic jam along highways leading to the path of totality. But during this eclipse, Calcutta transport authorities went to the extent of suspending local bus services and holding back the long-distance ones. Instead of Ankola, this time the crowds headed for Kurukshetra, for a holy dip. Among the pilgrims, who included sadhus, were some politicians.

All this brings us to the question, why should informed people propagate myths or observe rituals? Most people we spoke to knew how eclipses were caused, yet they claimed something evil was happening. If the atmosphere gets polluted during a solar eclipse and this is the basis for abstinence from food how come similar rituals are observed during lunar eclipses as well? How come the roofs on houses that keep off the sun's rays do not pollute? Probably it is the rarity of the natural event that has led to all this misinformation.

By the time the next eclipse occurs 15 years from now, people will have to be told all the facts once again, because the religious and ritualistic hold on us seems to be fairly strong. Nearly all the feedback we got from readers of the February 1980 issue of SCIENCE TODAY where we featured the eclipse was in connection with the brief article on myths related to the eclipse. Many people observed rituals so as not to offend their elders. Fifteen years from now their children will probably do it in order not to offend them. So much for tradition.

SUMATI SAMPEMANE

Miss Sampemane is on the editorial staff of SCIENCE TODAY.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Science Shapes Life

CHINESE TRAIN FOR SPACE MISSIONS

The Chinese are getting ready to put a man in space and are at present training their men, according to a recent report in *Aviation Week & Space Technology*

Chinese astronaut training seems comprehensive. At a Chinese space facility that is not named, the journal reports that the astronauts are undergoing zero-gravity, centrifuge and psychological tests The prospective astronauts are mostly young air force pilots.

Hand in hand with the training, the Chinese are also working on the development of space foods, that include "moon cakes". The cakes are wrapped in a membrane that will prevent crumbs from floating away under conditions of zero-gravity. Under testing are also space suits which will have provisions to supply food to astronauts

Although the Chinese have released details of their training programme, they have given no indication that they will soon have a man in space But it is certain that the Chinese are giving high priority to their space applications efforts

INSULIN FOR SLIMMING

We live in an age when over-eating is considered bad, being associated with the same feeling of guilt that in the past was associated with sex. A lot of research has been done on obesity and generally the feeling is that obesity results from hereditary as well as dietary characteristics. The latest bit of news on the subject concerns certain tests done on baboons.

Scientists at the University of Washington, Seattle, USA, got the clue from a recent finding that the brain has insulin receptors Besides, obese humans are known to have higher-than-normal insulin levels in the cerebrospinal fluid.

The Seattle scientists injected insulin into the brains of the baboons which, as a sort of corollary, made the baboons 'feel' obese. As a response to the trick, the baboons readily decreased their food intake by as much as 50 per cent. The scientists explain that insulin levels in the cerebrospinal fluid vary much less rapidly than insulin levels in the blood and thus may serve as the body's monitor for total food intake. They feel that obese humans have a defective insulin-sensing mechanism in their brains.

It is hoped that the research finding on the baboons may have important implications for the future in treating human obesity.

CURE FOR COLOUR BLINDNESS?

When light falls on the eye, it triggers certain chemical changes in the retinal pigment in the light receptor cells and thus begins the process of vision Each light-sensitive cell responds to a particular wavelength, but the same chemical compound, 11-cis retinal, is also responsible for our ability to see all the colours we can How does it happen?

Koji Nakanishi of Columbia University and Barry Honing of the University of Illinois report that a large protein molecule to which the retinal binds determines what wavelength (in other words, colour) the cell will respond to. Negative charges on the protein molecule seem to be the responsible factors, but the location of these charges varies for different colours it discerns. When the position of the charge is changed, Nakanishi and Honing report, the light absorbtion characteristic also changes.

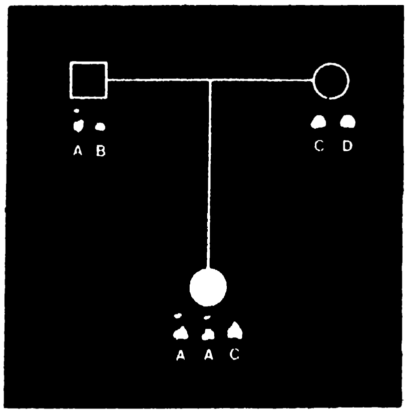
An experiment done with a synthetic analogue of the retinal showed that this synthetic molecule combined with the natural retinal binding proteins in the eye. This was proved by introducing the analogue in place of the retinal in living animals. Rats were deprived of vitamin A, a precursor to the retinal, and then injected with the synthetic analogue. They went blind When the retinal was reintroduced, they regained their sight The analogue was labelled and found to occupy the same place in the eye.

Nakanishi now hopes to introduce synthetic analogues that can react with the protein and help vision. When this is achieved, it will be possible to introduce proper analogues so that the

PATERNAL ROLE IN DOWN'S SYNDROME

Down's syndrome, also known as mongolism, is a chromosomal aberration. Human beings have 23 pairs of chromosomes. In the most common form of Down's syndrome, the afflicted baby has an extra chromosome (number 21) While in normal individuals there are two chromosomes of number 21, in the Down's child there are three. This is called trisomy 21 Down's. In another form of the disease, a bit of the chromosome 21 gets translocated onto another chromosome.

The main reason for the disease is thought to be advanced maternal age—when the egg cell has become defective But recent studies indicate that this is only one side of the story; advanced paternal age also seems to matter In atleast one-fourth of the cases, the defect, it was established, lay in the sperm R Ellen Magenis of the University of Oregon, USA, compared chromosomes of 61 Down's syndrome patients with those of their parents. In 49 cases, she could trace the chromosomal aberration to its specific parental origin and she found that in 22 per cent of the cases the flaw lay with the sperm. Other researchers have also obtained similar results



The square represents the father's and the circle the mother's chromosomes. Note that the extra chromosome comes from the father

According to a survey conducted in Denmark where 218 patients were examined along with 5,633 controls, it was found that the incidence of the affliction was greater when the father was 55 years old or more Japanese investigators have obtained similar results. There was a gradual increase of risk till the father reached 49 years, at 55, there was a sharp jump

Another strange finding was that markedly young parents also ran a high risk of having a Down's baby.

How come nobody suspected the father's role so far? The main reason was that until recently only four of the 23 pairs of human chromosomes could be identified. Then a Swedish scientist evolved a new staining technique, using a fluorescent dye called quinacrine mustard, by which all 23 pairs of the chromosomes could be distinguished. Following this, US scientists discovered a staining technique by which different regions of the chromosome could be identified It is these which finally led to the paternal factor to be precisely pinned down colour-blind can see colour. More exciting, it could be used to extend our visual range beyond the violet and red on either side of the spectrum. And how the brain can cope with and process this extra sensitivity is another aspect worth looking into.

SEX CAN HURT THE BABY

Sexual intercourse during the final stages of pregnancy can hurt the unborn baby, according to a report in the *New England Journal of Medicine*.

Richard L Naeye of Hershey Medical Center, Hershey, Pennsylvania, USA, collected data from nearly 27,000 cases. Women who had sexual intercourse once or more per week during the ninth month, he found, had greater chances of incurring amniotic fluid infection. This in turn could also lead to higher than average, fetal and neonatal deaths—especially in premature babies. Maybe, a large number and variety of bacteria gain access to the amniotic fluid.

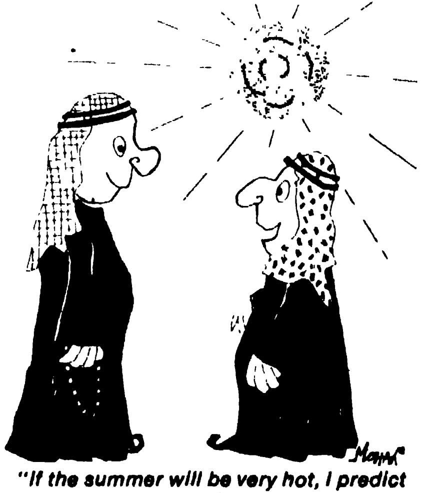
Naeye found that intercourse could lead to other problems as well. Premature babies of mothers who had sexual intercourse had breathing problems and low 'Apgar' scores. Apgar scores indicate the infant's physical fitness a minute after its birth.

WHY DO BEDOUINS WEAR BLACK?

They say light colours are more comfortable for wear in hot climates because they absorb less heat. Yet, Bedouins, the desert nomads, often wear black. Scientists from the Department of Zoology, Tel Aviv University, Israel, and from the Museum of Comparative Zoology, Harvard University, Massachusetts, USA, claim to have found the clue. For one, though black absorbs more heat, it also filters a great deal of heat. Earlier studies had shown that white hair on cattle and white feathers on pigeons allow greater penetration of shortwave radiation than black skin or black feathers. But, Amiram Shkolnik and his colleagues have found that, although black robes do absorb more heat than white robes, the excess heat is lost before it reaches the skin.

To measure the effects of colour on the heat load imposed on a Bedouin in a hot cloudless summer midday desert, the researchers compared the Bedouin robes in black and white, tan-coloured army uniforms and shorts. The Bedouin robes were used in two layers just as the nomads do, and the net heat-gain by radiation, heat storage and heat-loss, by both convection and radiation, were compared. The black robes absorbed 2.5 times more radiation (in the visible part of the spectrum) than the white ones, and 1.5 times more than the tan-uniform of the army or the shorts. But there was essentially no difference in the net heat-gain between the black and white robed individuals. The metabolic heat production was essentially the same. The surface temperature of the black robe was 47°C, and of the white, 41°C, whereas skin temperature in both cases was 31°C.

The researchers explain that the convective transfer of heat in air spaces in black robes must be greater than in white robes either by the bellows action as the robes blow in the wind, or in the manner in which hot gases rise up through a chimney pulling cooler air from below.



"If the summer will be very hot, I predict another oil price hike. If not ... well, there'll be another oil price hike."

THE MIXED-UP MOUSE

By clever manipulation, scientists can even produce a chimeric mouse with six parents. However, all the parents have to be of the same species. When rat and mouse chimeras were tried, it was found, the offspring was pure mouse, though the rat cells did function early in the embryonic life. Now, Janet Rossant and her colleagues at Brock University, Ontario, Canada, have successfully interbred two species of mice and got a perfect mixture.

The two species, *Mus musculus* (the common laboratory mouse) and *Mus caroli* (a wild species from Asia) do not normally interbreed; the difference between them is too pronounced for that.

The reason for studying the mixed species is to understand embryogenesis and how the cells contributed to the developing of the animal. And also if antigens that attach to cells of only one species are developed, they will serve as markers to map the descendants of embryonic cells and thus determine which cell gave rise to which tissue.

Rossant introduced cells from the embryo of the wild grizzly grey mouse into the embryo of the laboratory mouse and implanted it into a foster mother. Eighty per cent of the pups were a proper mix; they contained cells of both species. The blending of their coat colours, white and grizzly grey, was an indication of the mixing. Not all pups are mixed up in equal proportions; some do retain more characteristics of one parent than the others.

The piebald mouse

The chimeric mice are not sterile like the mule which is got by interspecial breeding. They can even mate with the original species and produce pups of the pure and mixed varieties.

SYNTHETIC BLOOD SUCCEEDS

One advantage of synthetic blood is that it can be given to anyone irrespective of his blood group; the other is that it eliminates transmission of diseases. It has also a long shelf life. Many groups of scientists have been working for years for an artificial blood (SCIENCE TODAY, April 1973, p. 10). But it is two Japanese scientists who say they have evolved a synthetic substitute at last. The substitute consists of a mixture of yolk product, starch and perfluorochemicals. Called Fluosol-DNA, the blood substitute carries more oxygen than does the natural blood. The chemicals used do not accumulate in the body.

In an experimental trial, when Fluosol-DA was used to replace 90 per cent of rat's blood, the rats returned to normal blood levels within two weeks. Reporting this at a meeting of the Chemical Society of Japan, Japanese scientists, K. Yokoyama and R. Naito of Green Cross Corporation, Osaka, claimed that 98 per cent of the natural blood could also be replaced in monkeys by the synthetic substitute.

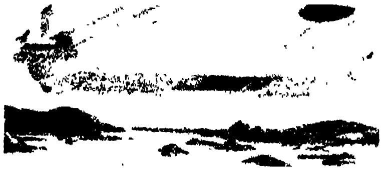
In the US, artificial blood, also made from perfluorocarbons, has been successfully used in man. The blood obtained from a Japanese drug company was given to a severely anemic man whose religious belief forbade blood transfusion (Jehova's Witnesses are forbidden blood transfusion since the process is akin to eating blood, and eating blood is forbidden in the Bible). Robert Anderson sought the FDA's permission for the transfusion. The patient was given two litres (roughly 25 per cent of his total blood volume) of the artificial blood. This was excreted from the body slowly in about a week. Meanwhile, his marrow had produced enough blood to correct his anemia.

WILL AIRSHIPS COME BACK?

It looks like the world will soon have to bring the airships back (see SCIENCE TODAY, June, 1975, p 51). Of course, the airships of the future will not be like the great *Hindenburg* which caught fire in May 1937, after which the world saw the airships relegated to history. Airships of the future will certainly be larger, up to a third of a mile long—and they could use nuclear power, corrosion-resistant alloys for the body, tough nylon fabrics for the "skin" of their gas cells, and helium gas in place of the highly flammable hydrogen that was used in the past. But why the airships again?

The answer is obvious: dwindling fuel resources and the need to carry increasing loads across continents. Today the goods carried by aircraft have most often to be transferred to other vehicles before their destinations are reached, but airships can land anywhere provided there is enough space.

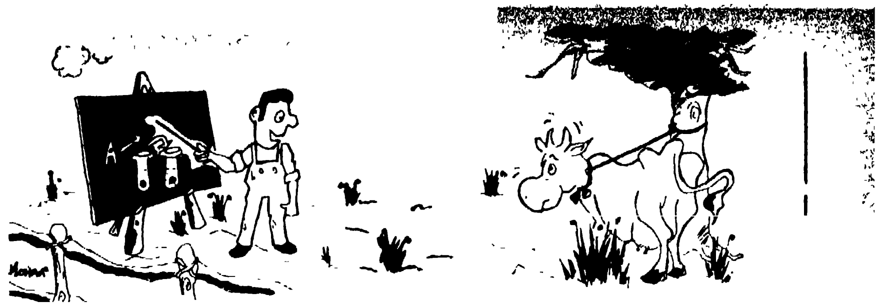
Airships of the future will be much safer than the ones used in the past Since World War II, materials that can be used for constructing airships have improved a great deal Besides, another great boon to the safety aspect will be a sophisticated on-board computer that will monitor weather as well as overall conditions aboard the airship



A deltoid airship For short periods, it can run solely on solar energy

Nuclear-powered airship designed by Boston University. The cutaway section shows living and working quarters

Because it uses the "lighter than air" principle to fly, the airship will require practically no fuel to take off unlike a conventional aircraft that burns up fuel to build up the thrust that will lift it off the ground. And once in the air, an airship, although slower than the commercial aircraft of today, can be propelled along at great fuel economy. Not only that, the airships will not pollute the atmosphere, not even with noise.



"And now I'll describe the in vitro technique..."

EMBRYO FOR SALE

While England boasted about its first auction sale of cattle embryos at Reading, recently, the US has already more than 20 commercial firms doing a roaring business by selling the frozen cattle embryos The feat of transferring a fertilised ovum (embryo) in animals can be traced way back to the last quarter of the 19th century.

In cattle, embryo transplant is done with fair accuracy. The 'donor' cows are treated with fertility drugs (gonadotropins) which usually result in superovulation, producing eight to 10 or more eggs. The eggs are then fertilised by artificial insemination with sperms from the select bulls The resulting embryos are allowed to grow in the natural mother for 6-8 days, then are flushed out of the uterus and are stored in a suitable growth medium for 24 hours. The viable embryos are chosen and transplanted immediately or stored frozen. The 'recipient' cow is treated with prostaglandin hormone (Pg F2 alpha) to attain the same stage of oestrus cycle as that of the 'donor', before the embryo is implanted in its uterus, through a small incision made in the abdominal wall and the uterus. After the operation, the 'recipient' cow undergoes normal pregnancy. The resultant 'calf' owes nothing genetically to its 'host' mother who merely acts as incubator. Perhaps in a few years time, there may be non-surgical implantation too

This method of animal breeding has multiple advantages. The foremost is the time factor. The farmer can rapidly 'build-up' a first rate herd, which would otherwise take him many years. International trade in cattle could become much cheaper, for the embryos are much lighter and easier to airfreight than cattle The latest freezing techniques also permit the necessary time to determine the sex of an embryo

The success story of cattle breeding by embryo transplant gives way to speculate whether it will be followed in human reproduction. Although several 'test-tube babies' have been delivered safely, still there are crucial differences between the philosophy and practice of human and animal reproduction. Transplanting the embryo from one woman to another sounds far-fetched at the moment If it becomes feasible, it may solve the 'fertility' problems faced by several women

PSYCHOLOGISTS STUDY THE JONESTOWN MIND

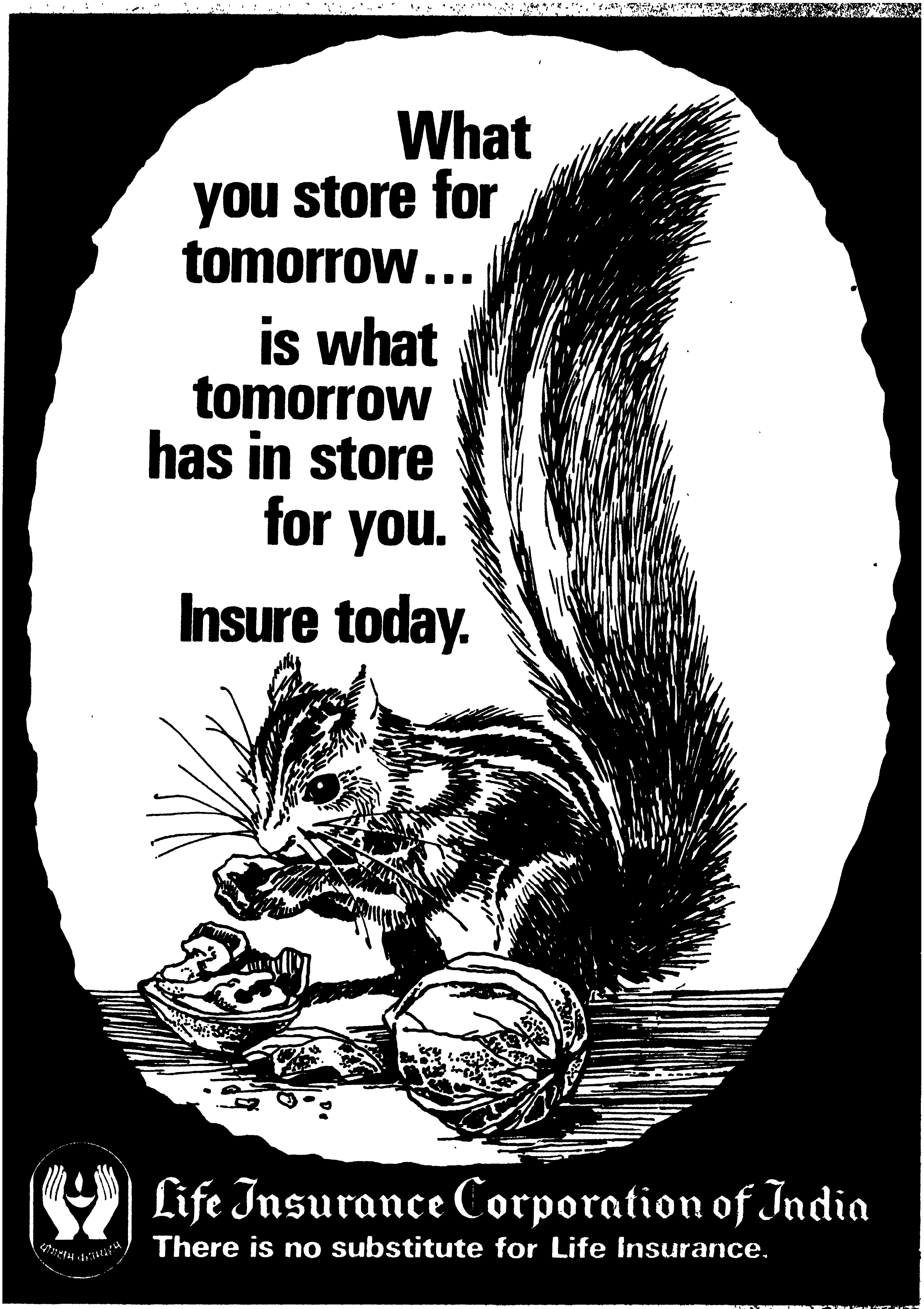
One major incident that has aroused the interests of behavioural scientists in recent times is the mass suicide of November 1978 by Jim Jones and his People's Temple followers at Jonestown, Guyana. How could one mind possibly have caused the self-slaughter of over 900 persons?

The understanding that has come from the studies is that Jones used intricate psychology to impress his followers. For instance, even before a new follower was recruited, Jones would gather minute information about him with the help of his men.

Later, on the day the new person came to Jones's community, he saw Jones first at one of his lecture sessions. And Jones would begin his address thus, "I sense the presence of a Mrs. Margaret Layton who suffers from diabetes and who is under the care of a Dr. Johnson." Anybody would be impressed by something like that and think Jones must have divine powers. Says M.T. Singer, a University of California clinical psychologist, "The recruitment was very sophisticated .. Jones was a modern master of deception "

Once in the commune, Jones saw to it that he had absolute control over his followers' property, a sort of control a father has over a child Other methods adopted by Jones was to weaken all family ties the followers had by building up a sort of sociopolitical caste system within the commune "Common members were absolutely powerless", says another psychologist, Jose I. Lasaga of the University of Miami.

Lasaga and others studying the life at Jonestown feel Jones was all the while using the methods of a hypnotist. He managed to close all channels of communication with the external world except one—himself Such a cognitive and emotional control of the mind alone could set the stage for one of the most astonishing instances in human history. It's no wonder why even some Jonestown survivors still cling on. One such People's Temple member was recently quoted as saying: "Had I been in Jonestown on 18 November 1978, I would have been the first in line to take the poison, if I had been so honoured."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Insure today.
Life Insurance Corporation of India
There is no substitute for Life Insurance.

The evolution of behaviour

Sociobiologists explain all behaviour in terms of genes

Madhav Gadgil

ONLY recently have biologists begun to make sense of the endless variety of social behaviour amongst animals. It is a repertoire as fantastic as it is diverse. Consider the scenario: A hungry bear is inching up a tree to get honey. Suddenly a black cloud of bees swoops down to repulse the intruder. Hundreds of bees give their lives in a kamikaze-like suicide attack. For to sting, for a worker honeybee, is to die. Yet there is no dearth of bees who are willing to sacrifice their lives. In another part of the same forest, an adult male hanuman langur is busy killing baby langurs. He has just taken over a new troop and is ensuring that none of his predecessor's progeny survives. While groups of animals like hyenas, wild dogs, wolves, etc help each other in running down their prey, cheating his own kind seems to come naturally to a minor male weevil who creeps under a major male guarding his mate and stealthily copulates with her.

My son my extension in time
– Christopher Fry

The new understanding of animal behaviour may be traced to two seminal papers on the genetical evolution of social behaviour published by William D. Hamilton fifteen years ago. Hamilton showed that all social behaviour might be classified into four categories—selfish, altruistic, co-operative and spiteful—depending on who gains and who suffers in any social exchange. Surprisingly, some six centuries ago, the Sanskrit poet Bhartrihari had come up with a similar classification of social behaviour. According to him there are four categories of people: the holy men or altruists who help others even at a cost to themselves; the commoners or co-operators who will help others only if it coincides with their self-interest; the demons or selfish who will even hurt others if it serves their self-interest; and the spiteful who hurt others for no reason whatever. This last category, the poet says, he fails totally to understand.

A selfish act is one in which the actor gains and the recipient suffers — like that of a dominant monkey snatching food from a subordinate one. A squirrel warning its companions of a predator even at the risk of attracting the predator's attention is an instance of altruistic act; here the actor suffers and the recipient gains. One chimpanzee helping another to run down a vervet monkey is a co-operative act in which both the parties gain meat. A spiteful act is cutting one's nose so that it serves as an ill omen to another, but in the sub-human animal kingdom there are no convincing examples of such behaviour in which both the actor and the recipient suffer. (Fig 1)

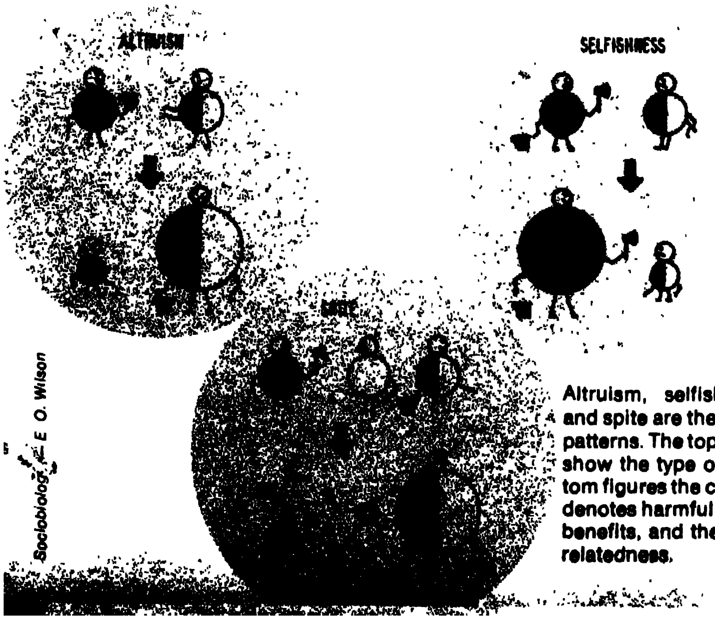


Fig.1

Altruism, selfishness, co-operation and spite are the four basic behaviour patterns. The top figures in each circle show the type of action and the bottom figures the consequence. The axe denotes harmful action, the vessel the benefits, and the black the degree of relatedness.

Sociobiology — E O Wilson

The selfish and altruistic genes

How are these gains and losses measured? In evolutionary biology, all such measurements are made in units of genetic fitness, and genetic fitness is measured in the currency of offspring. Consider an animal which has just attained reproductive age; its genetic fitness is given in terms of the number of its offspring expected to survive to the reproductive age In other words, it is a measure of the number of copies of genes (or hereditary units) an animal contributes towards the hereditary composition of the next generation. If a given gene confers upon its bearers the ability to leave behind more copies than does an alternative gene, then the former will slowly replace the latter from the hereditary composition of the population. This process of the swamping of the gene pool by genes which replicate faster than their competitors is the process of Darwinian natural selection. Natural selection would then favour those genes which confer on their bearers the ability to survive and reproduce better.

This means that natural selection would, in general, favour selfish traits. Therefore, when a monkey snatches food away from a weaker one it is, in effect, enhancing its own ability to survive. If this trait of snatching food was hereditary, then the gene for such a trait would certainly spread in the population. And of course all the evidence we have at our disposal does go to show that selfishness is widespread in the animal kingdom. Animals continually strive to get more food, better nesting sites, better protection from predators, better access to mates in competition with other members of their own species, and one can easily see how such tendencies would be favoured by natural selection. But how can one explain the reverse? How could altruism be favoured by natural selection? For genes which prompt their bearers to do so should reduce their chances of survival or reproduction. Their bearers must therefore end up leaving fewer copies of such genes behind than those of alternative selfish genes; consequently, altruistic genes should eventually be eliminated from the population.

Evidently this is not always so. Worker bees do throw away their lives in defence of their hives, squirrels do risk drawing attention of the hawk while squealing out alarms to others, and wild dogs do regurgitate meat for their pups. There must therefore be circumstances under which altruistic behaviour can be advantageous. Conditions under which this is possible is in fact one of the most challenging problems in modern biology

Altruism could evolve along one of three routes: (1) in the interest of the group as a whole, (2) in the interest of the blood relatives of the altruist, or (3) as a part of a 'you scratch my back, I will scratch yours' deal.

The first explanation, that of group interests favouring altruism winning over individual interests favouring selfishness, was developed by V. C Wynne-Edwards in 1961 He suggested that animal populations always run the risk of extinction through the overexploitation of food resources. Unless their rate of increase was checked, they would quickly exhaust their resources and go extinct (Fig 2). Therefore, Wynne-Edwards suggested, much of social behaviour was geared towards an adjustment of population densities.

Altrusium versus selfishness Consider a model of a population which has a number of discrete habitats available for occupation The populated habitats may be dominated by selfish individuals (S) or altruists (A) Their composition may change by altruists being swamped out by the selfish or they may become empty by extinction Populations dominated by selfish individuals are much more likely to become extinct, whereas the selfish do not swamp out the altruists as quickly That is, the transitions S→E are very frequent and A→S not so frequent Under these conditions, it is possible for the majority of population to be dominated by the altruists Indicated in the figure below is a population spread over 12 potential habitats At some time *t*, habitat 1 was dominated by altruists and 5 by the selfish at the next time interval *t + 1* habitat 1 was dominated selfish while 5 became empty and so on The particular transitions depicted here indicate a steady state with five populations dominated by altruists and three by selfish, the other 4 habitats remaining empty

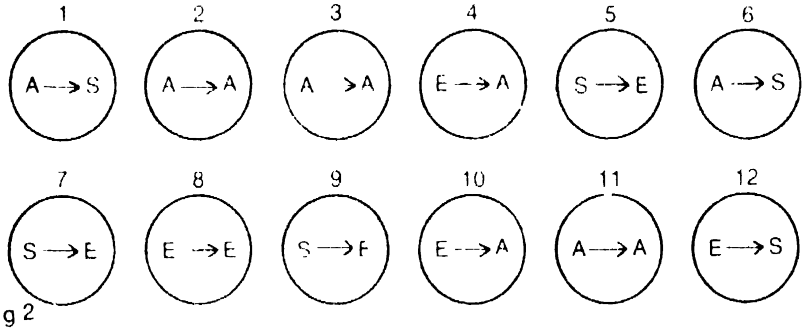


Fig 2

How selfish is the selfish gene?

Sociobiology is a study of genetic self-interest. According to this science, the chief test of human (and animal) behaviour is the efficiency with which a person can project himself (in other words, his genes) into the future. Every act is worked out on a cost-benefit ratio—even in day-to-day life—according to anthropologist, Irven DeVore of Harvard University, USA.

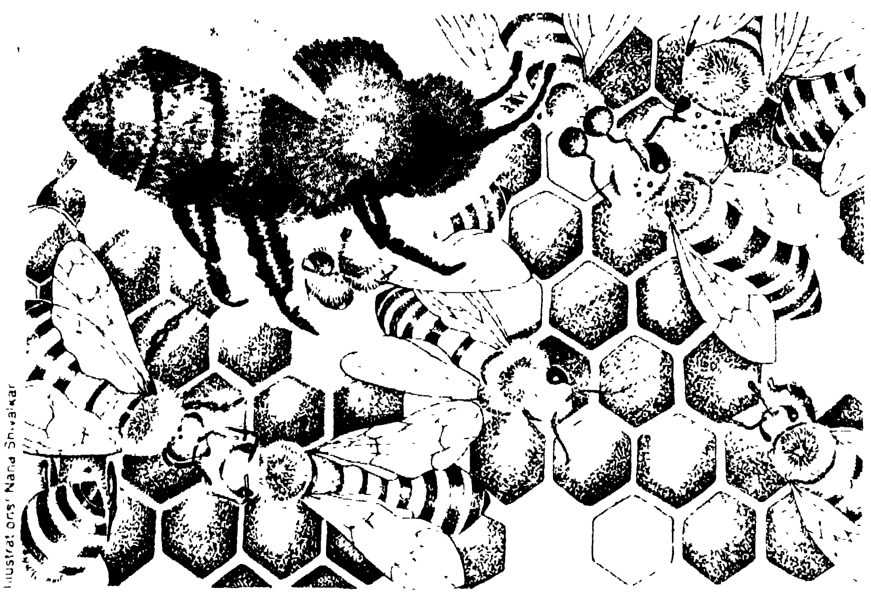
In an interview with *Psychology Today* (February 1977), DeVore emphasises that it is the reproductive success of an individual that is most important to him. Only next to self selection came kin selection. Following this, of course, were other relationships that helped ultimately in favouring one's genes.

Theoretically, says DeVore, a person is in conflict with everyone—even parents and children—except his identical twin; he views every situation according to his gene investment in it. All children, he argues, are equally related to a mother, so she would encourage one to help the others as long as the cost to the helper does not exceed the benefit to the other. But the siblings themselves would view it differently. Since they are related by only 50 per cent the helper will consider worth his while so long as the benefit to his brother exceeds his cost by twice as much or more. Similarly, in the relationship between aunts/uncles and nieces/nephews and cousins, the aunt being genetically related to her nieces and nephews would like her own son to help them so long as the cost to him is half the benefit to her niece. But the son doesn't think so. To him his cousin is related to him by only one-eighth (12½ per cent). He will be inclined to help so long as the cost-benefit ratio is 1:8 or better. Here then is a conflict. Parent and offspring differ vastly on how much a sibling or cousin could be helped.

That people favour their own offspring is universally known and accepted. Why else would people remark on a person's good treatment of an adopted child or stepchild. Every folklore and mythology testifies how rare an occurrence this is. 'Stepmother' is often a synonym for cruelty.

As regards the differing attitudes of the two sexes to adultery, DeVore holds that the woman is more tolerant because desertion for her is a greater calamity; isn't her investment in raising the children much more than the man's? It follows that the man will be less tolerant of adultery because the chances are he may have to raise another man's child; this will delay the reproduction of his own genes. DeVore relates the story of an

Altruism also helps in self-replication. In the case of the honey bees, it is thought, the unique genetic make-up called haplodiploidy is responsible for the altruism



Illustrations: Nana Shivalkar

Voluntary relinquishment of reproduction by a fraction of the population, sufficiently large to keep it at a level at which it did not exhaust the resources, would naturally help. Such voluntary relinquishment of reproduction by some individuals while permitting others to breed is of course altruistic behaviour.

But Wynne-Edwards's theory has led to considerable debate. The consensus now is that the conditions under which the postulated group selection could operate are realised only rarely in nature. Moreover, most of the phenomena considered by Wynne-Edwards are more readily and convincingly explained as a result of ordinary natural selection. His theory is therefore believed to have little explanatory value.

Sex ratio

The ratio of male to female offspring of any individual is an example of a phenomenon readily explained by natural selection, but posing considerable difficulties for group selection. In the majority of animals this sex ratio at birth is close to 1:1 Since population growth is limited primarily by the number of females in most animal species, group selection arguments would suggest that the ratio should greatly favour males to avoid excessive population growth. This is almost never the case in any animal species. On the other hand, the prevalence of 1:1 sex ratio is very easily explained on the basis of natural selection.

The key to this lies in the equal contribution by both parents to the hereditary constitution of the next generation (Fig 3). If there is an imbalance of sexes in the population, any individual of the minority sex must necessarily on an average make a greater contribution to the hereditary composition of the population in the next generation than an individual of the majority sex. Thus, if a population has nine males to one female, any female would on an average contribute nine times more to the heredity of the next generation than a male on an average would. Hence a gene coding for producing more offspring of the minority sex would leave more of its copies behind. This would lead to a reduction in the proportion of the majority sex till the imbalance is redressed.

Ties of blood

Selection in the cause of group interest may operate to a limited extent, but is unlikely to be widespread, and is therefore not a satisfactory explanation for altruistic behaviour. The clue to the origin of most of altruistic behaviour in the animal kingdom lies in such behaviour being directed towards one's blood relatives. Aunts of elephant calves and lion cubs protect and nurse them, ground squirrel females utter alarm calls to warn others of danger only when they are in the vicinity of their own sisters and daughters, and honeybee workers give their lives in the defence of their mother and sisters. Thus animals often tend to be altruistic towards

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Eskimo who married a woman who had a nursing infant by her first husband. The new husband decided to kill the baby as it had another father. Such behaviour has also been noted among lions, langurs and other animals (see SCIENCE TODAY, January 1976, p. 52 and January 1979, p. 35).

On cases of adoption, DeVore says, people tend to adopt the close kin. Where this is not the case, the adoptee, who has no common genes, helps in increasing the reproductive efficiency; in some societies they grow up to become the wife or a concubine. Sometimes the adopted children act as 'helpers in the nest', caring for the household, but when it comes to distributing the property, the natural children are usually the beneficiaries; the adopted children are left out. Even when the outsider is made heir to the property, he usually ends up by marrying the person's daughter so that the benefits stay in the family.

Often, people will their fortune to their grandchildren; this is especially so when the parents have married against the grandparents' wish. This way the grandparents are investing in children who carry their genes rather than in their offspring's spouse who does not.

Another interesting genetic strategy is cousin marriage. In elite families, it is done to keep the wealth within the family: the beneficiaries, ultimately, are both relatives — one's own genes.

But why does a person help a friend or a neighbour? DeVore explains that here one does not expect immediate repayment, he relies on the subtle build-up of credit in the indebted person's mind. Won't the friend feel obliged to repay the good turn? Of course, there will always be people who will try to take advantage of this social norm and not repay the debt. This happens ever so often with a stranger in an urban setting. That is probably one of the reasons for an urbanite's indifference and desire not to get involved with strangers. But all the same, we do stress the importance of mutual obligations among members of a society, since it encourages reproductive success.

Though it is not always obvious, genetic strategies seem to underlie even simple acts. Millennia of evolution has equipped people with a whole complex of motivation, inclinations, propensities and emotions that guide human behaviour. These emotions do affect genetic self-interest (example: a mother trying to make a good match for her daughter), though, in most cases, the adaptive consequence may not be obvious. Co-operation, altruism and also competition are natural, all depending on whose genes the person bears.

SUMATI SAMPEMANE

Miss Sampemane is on the editorial staff of SCIENCE TODAY.

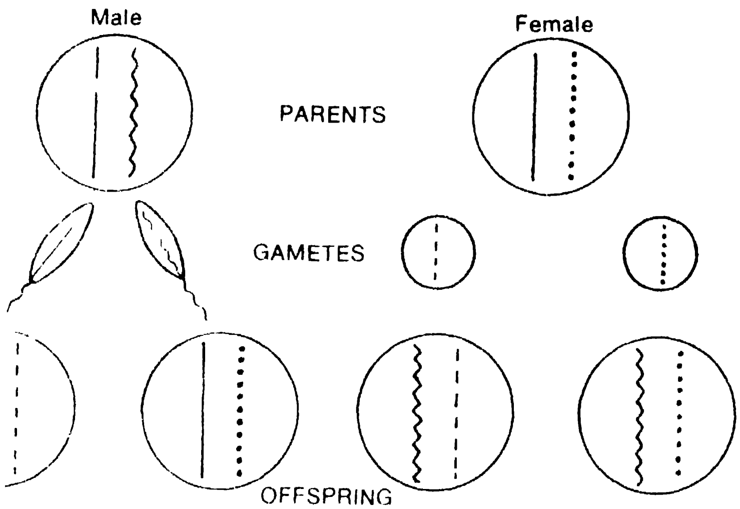

Fig 3

What makes blood thicker than water ? It's the number of common genes between individuals. There are two sets of chromosomes in each cell in most animal species: one set is derived from the mother and the other from the father. Therefore, given that an individual's parents are not blood relatives, he shares half his genes with his father and the other half with his mother. Similarly, there is a half probability that any gene that he has is also with his full sister (or full brother), a probability of one-fourth of any given gene that he shares with his grandparents, aunt or uncle, of one-eighth with his first cousins, and so on.

...all is fair in love

MUCH of social behaviour involves one animal persuading a second to act in a way it would like it to behave. An elaborate network of communicatory signals has evolved to serve this end. Thus in the three-spined stickleback fish, a male advertises his being sexually competent by his red belly. This is also a warning to other males to keep out of his territory and an invitation to females to visit his territory. This stream breeding fish builds sand nests in his territory. The females lay eggs in his nest, which he fertilises and takes care of.

The male tries to mate with as many females as possible since it improves his reproduction efficiency. Occasionally, when he has just persuaded a female to come to his nest, he may notice another female at the edge of his territory. He may rush to invite the second female to his nest even before he has had a chance to fertilise the eggs laid by the first female. But, Desmond Morris discovered many years ago that the second 'female' only looks like and acts a female; the fish is in fact a sneaking male in disguise, lacking the red belly. While pretending to lay eggs the pseudo-female fish fertilises the eggs of the first female. After the sneaker leaves, the proud owner of the territory attempts to fertilise the already fertilised eggs often unaware of the trick that has been played on him. This particular variety of deceit belongs to the class known, naturally enough, as 'sneak fucking'. The study of deceit in animal kingdom is now arousing considerable interest.

M G

other animals which share in common a large fraction of their hereditary units or genes by virtue of common ancestry.

J.B.S. Haldane put across this point very colourfully when he said that he might be willing to throw away his own life to save the lives of two full brothers, would certainly do so to save the lives of three full brothers, but would not be willing to do so to save the lives of three half-brothers. Consider a gene coding for the altruistic behaviour of sacrificing one's life for saving the life of a relative such as a full brother. Since, on an average, an individual shares half of his genes with a full brother (Fig 4), two full brothers should carry on an average one copy of such a gene in common with an individual bearing it. So in sacrificing oneself to save the lives of two such full brothers, the one copy of the bearer will be lost to save on an average one copy in the full brothers saved. So the benefits and costs of such an act from the point of view of the altruistic gene are even. Similarly, three full-brothers will, on an average, carry one-and-a-half copies of such a gene. Hence, sacrificing one copy of the gene by the bearer to save the loss of one-and-a-half copies in the three brothers will certainly be favoured by natural selection. On the other hand, half-brothers share only a quarter of their genes with each other. Hence, sacrificing one's life to save three quarters of a copy of the altruistic gene in three half-brothers would not at all be favoured by natural selection.

An explanation for matriarchal societies?

THE modern theory of natural selection suggests that an individual is best off directing his altruistic behaviour towards his blood relatives and that the intensity of this altruism will increase with the closeness of their blood relationship. In a society where polyandry is prevalent, the children of a man's wife or wives are not always his biological children; he may have no blood relationship whatsoever with them. On the other hand, his sister's children will have a certain degree of blood relatedness with him. At an absolute minimum, they will share one-eighth of his genes. In a polyandrous society it may therefore be often of greater genetic advantage for a man to care for his sister's children than for his wife's children. In such a society, then, we expect the property inheritance to be through the female line, and the mother's brothers and not mother's husbands to act as heads of the household. Biologist Richard Alexander, in fact, finds such a correlation between polyandry and maternal uncle care in many societies of American Indians. Similar cultural behaviour prevails on our own Malabar coast, and, according to Mahabharata, prevailed amongst the robbers hailing from Aratta.

This is not to suggest that polyandry and maternal uncle care is genetically programmed in such societies. Indeed it is not. What is suggested is that along with the rest of the social animals, human beings have a genetic predisposition towards caring for their closest blood relations. Since in a polyandrous society these may be the man's sister's children, cultural practices will evolve to conform to this genetic preference.

M.G.

Since blood relatives are expected to share a significant fraction of genes with an individual, sacrifices to enhance their genetic fitness can be favoured through natural selection. W.D. Hamilton showed that altruistic behaviour will evolve through natural selection so long as the cost of such behaviour to the altruist is less than the benefit of the act to the recipients multiplied by the fraction of genes of the altruist shared by the recipients. Thus the cost of an act to the altruist should be less than half the value of the benefit to a full brother, or less than one-fourth the value of the benefit to a half-brother, and so on. Similarly, this theory predicts that selfishness in behaviour towards blood relatives will be constrained. The benefit from a selfish act which hurts an individual's full brother should exceed half the cost of such an act to the full brother or one-fourth the cost of such an act for a half-brother, and so on.

Social Insects

The calculus of kinship takes on a special form amongst the wasps, bees and ants. In these animals, the males develop from unfertilised eggs, while the females or workers develop from fertilised ones. In consequence, a female is related by half to her mother, while she shares three-fourths of her genes with her sister (Fig 4). Therefore, it is genetically more profitable for her to help her mother produce more daughters, which are her sisters, rather than to produce daughters herself. This interesting asymmetry may be responsible, at least in part, for the great flowering of sociality amongst wasps, bees and ants.

But if to a bee, a sister is closer than a daughter, a brother is only half as close as a son. For a bee's brother shares on the average one-fourth of her genes, while her son has half of her genes. Hence, although it is genetically more profitable for a female bee to let her mother produce sisters, it is genetically better for her to produce her own sons rather than let her mother produce brothers. This leads to a very interesting mother-daughter conflict of interest. In an elegant paper, in 1976, Robert Trivers explored the consequences of this conflict. He showed where possible workers (females) will attempt to lay male eggs. Where this is impossible, the workers tend to devote thrice as much effort to the rearing of sisters, since sisters are genetically thrice as close to them as are brothers. And indeed this prediction was neatly borne out by the data he went on to collect.

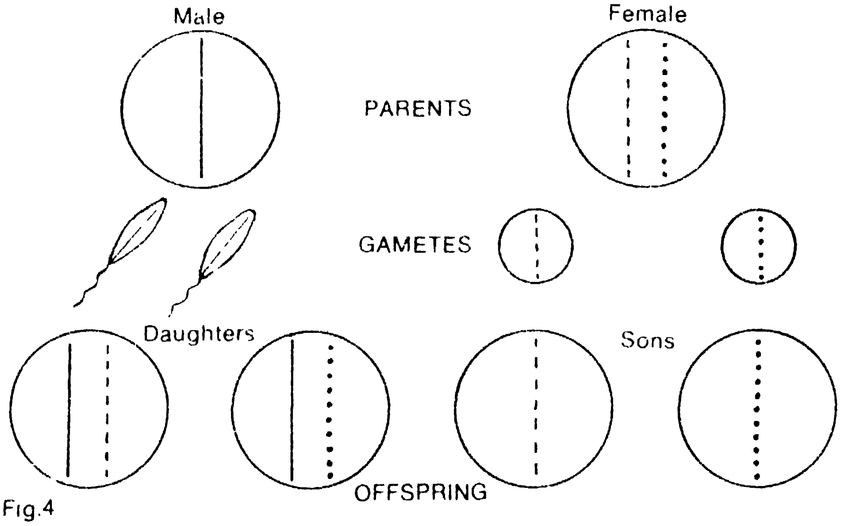

Fig.4

In the haplodiploid species such as ants, bees and wasps on the other hand, the males are produced from unfertilised eggs and contain only one set of chromosomes The females, on the other hand, are derived from fertilised eggs and contain two sets of chromosomes Since the father s sperms are all genetically identical, the sisters share all their paternal genetic material and half of their maternal genetic material Hence, sisters are genetically related by three-fourth, mother-daughters by half, mother-son by half and sister-brother by one-fourth These genetic asymmetries have very important consequences in social behaviour patterns

Deceit

If it is to the genetic advantage of an individual altruistically to help a blood relative, it will be advantageous to others to pretend to be a blood relative. Some slave making ants do just this. These ants raid colonies of the 'slave' species and steal their brood. One of the devices used by the master ants to gain entry into the victims' nest is to pretend to be a blood relative of the slaves. All the workers of an ant colony constitute a sisterhood, and recognition is by the common colony odour specific to each colony; strangers are thus kept at bay. Some species of master ants acquire this odour by cunningly mingling with the slave workers when they are out foraging. Having masked themselves, they slip in without being recognised as an alien and accomplish the kidnapping. When the kidnapped brood grows up they serve as slave workers for the colony of the 'master' species.

Mutual backscratching

It turns out that almost all of the altruistic behaviour in the animal kingdom is explicable on the basis of help rendered to blood relatives. But this is not the whole story, particularly in the higher mammals and humans. In the troops of the African olive baboon, for example, quite unrelated males may form pacts to help each other in fights with other males of the troop, particularly when there is competition over the females in heat. A careful study by W.C. Packer has demonstrated that the male baboons consistently help those who came to their aid in the past when they were in conflict with others. This is a baboon version of the 'you scratch my back and I will scratch yours' contract.

In humans, this kind of mutual back scratching—technically known as reciprocal altruism—is the basis of a large proportion of social dealings. And where any possibility of obtaining social aid exists, there evolve elaborate devices to achieve it. There is a Marathi proverb that describes it

Superaltruism

THE best example of altruism is seen in slime moulds. Slime-moulds, also known as soil amoebae, are primitive one-celled organisms which live by preying on other smaller organisms found in the soil. Theirs is the most primitive society we know about. When the going is good, the organisms live as single-celled predators and divide into two daughter cells from time to time; under adverse living conditions, they come together to form a single multi-cellular organism called the slime-mould slug. This slug creeps about for some time, and then forms an erect structure with a stalk bearing a fruiting body aloft. The cells in the fruiting body form resistant spores which are dispersed. If a spore chances upon favourable conditions, its resistant wall cracks and the soil amoeba emerges and begins its predatory existence once more.

However, the cells that go to make the stalk have no chance of survival Thus, some soil amoebae sacrifice their lives so that others may survive as spores, tide over the adversity and find a better environment to live and multiply This is altruistic behaviour *par excellence* What do the dying cells gain? The explanation is that all the cells that come together to form the slug are derived by divisions of a single common ancestor. They are therefore, genetically identical. Hence, any of them would be favoured for sacrifice so long as the benefit of such a sacrifice exceeds the cost to the altruist. This evidently holds true; without a stalk to raise the spore-containing fruiting body, none of the cells would have had any chance of survival. So some altruists behave in such a way that they trade the chance of certain death for all, for some possibility of survival for a few.

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aptly. It goes like this: to exchange a gooseberry for a pumpkin! In such a mutual social aid system, evolution always favours the ability to convince others that you are doing much more for them than you really are. As everybody tries to pull off the same trick, there will be great evolutionary advantage for those who can see through such false claims of the others and catch those who are trying to cheat by welshing on their obligations. It is likely that we owe our highly developed brains to the importance of the mutual aid system in human social behaviour, and to the need to be able to see through the deceptions and cheatings in such system.

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Selfishness is the gene's way of self propagation. Male frogs fight to secure a territory in order to establish a breeding area to attract a male and thus improve his breeding efficiency

Why we behave as we do

How much can we extrapolate from animal behaviour?

V Nanjundiah

Is our behaviour determined by our genes? This is one of the interesting questions scientists are now asking. Certain features of living organisms are inherited; for instance, children resemble parents. Instincts also, it is suspected, have an innate cause, though the nature of this cause remains a puzzle. Perhaps the most striking characteristic of living beings is the extent to which they seem to be designed to fit a particular role. In fact, many of the older theories of living creatures degenerated rapidly into teleological reasoning. For example, we have eyes 'in order that' we may see; eyes are able to detect colours 'because' it is useful for us to do so (green apples make us sick), and so on. Behind such reasoning, of course, was the idea that the living earth was a system approaching perfection, existing particularly to cater to human, and to a lesser extent to non-human, needs (a philosophy whose latter part is still prevalent). In contrast, modern theories attempt to furnish both an immediate and a long-ranging structural explanation for all observations.

Both these explanations are equally valid and also causal; but the causative events themselves are far removed in time in the two kinds of explanation. On this basis, we would say that we can detect colours because: (a) there are certain molecules in the eye that can specifically absorb light of different wavelengths, (b) the ability to detect colours is a heritable trait, and (c) in the distant evolutionary past, those of our immediate forebears who possessed this ability left behind more offspring than those who lacked the ability.

Since the time of Charles Darwin, an attempt has been made to also explain behavioural traits with arguments similar to (b) and (c) above. In particular, there has been an attempt to understand behaviour in terms of the activity of nerve cells and their connections (the immediate explanation) as well as in terms of specific structural entities, genes, which are heritable and have evolved to code for the observed behaviour (the long-range explanation).

Within the range of different kinds of behaviour that living systems exhibit, the most complex are probably those which involve interactions between individuals of a social group. The study of such interactions, sociobiology, is an attempt to (a) abstract certain selected features of social behaviour occurring in nature, and (b) explain these on the basis of the genetical theory of natural selection.

Natural selection

Living beings possess heritable traits. Now, if the possession of one such trait X enables an individual to produce a higher than average number of offspring which survive to maturity, the population will, in the course of time, come to consist of relatively more and more individuals of type X. Living organisms are made up of units (called cells) which contain the hereditary material (called genes). Genes are large molecules capable of faithful self-replication. And the set of different genes of an organism constitutes its genotype. The genes also carry within them the information for various characteristics of the organism which are manifested in its phenotype.

The term phenotype includes many things, ranging from, say, the size the organism attains at maturity to the pattern of signals it uses in communication. The information contained in the genes is like the plan for constructing a complex structure which is put to use right from the start. The structure can be compared to the phenotype. The detailed nature of the final structure which emerges depends not only on factors in the plan, but also on the quality of material used, the weather, the degree to which changes are incorporated based on previous experience with earlier parts of the same structure, and so on. Thus, the actual expression of the phenotype depends on non-heritable factors as well. Take, for example, nutrition; it is a crucial factor in deciding the extent of growth. If there are individuals of different genotypes existing in a given environment, their phenotypes will vary as well. If some of the phenotypes are fitter than the others, that is, capable of leaving behind more offspring than the others, the frequency of their *genotype* in the population will increase. Thus, natural selection acts on the phenotype; but, as a consequence, it changes the relative numbers of genotypes in a population too.

Dolphins co-operate to help a wounded animal to rise above the water to breathe

This conclusion depends on a crucial assumption: namely, that there is indeed an underlying genetic basis for the phenotypic variation within a population. The following example should illustrate the importance of the assumption. People who cross the street haphazardly in Bombay perhaps have a low probability of survival, let alone that of producing children in the future. On the other hand, watchful crossers are likely to survive to have children as well as teach their children the habit. Ultimately, the population should consist entirely of individuals who exercise deep thought before crossing a road, though in terms of their genetic make-up they are probably not different from the others.

To the extent that genetic variations exist and affect differential reproduction, the theory of natural selection predicts that organisms adapt themselves to their environment. In other words, natural selection is directed towards making an organism more and more finely tuned to its environment. The reason again is that the less well-adapted individuals will leave behind fewer progeny than the rest.

Genetics of behaviour

Let us now look at some of the evidence which suggests that patterns of behaviour can be transmitted from parents to offspring. In those species in which parental upbringing is absent, any sort of complex behaviour that is spontaneously expressed is very likely to be innate. For example, a female digger wasp has to emerge from her nest in the ground, mate, dig a new nest of her own, construct cells in it, kill prey and stock the nest with them, lay eggs, and seal up the nest. All of this has to be done within the few weeks of her adult life. Such a tight schedule could hardly be accomplished by trial and error; it is likely that the entire sequence of behavioural steps is coded for in the wasp's genes.

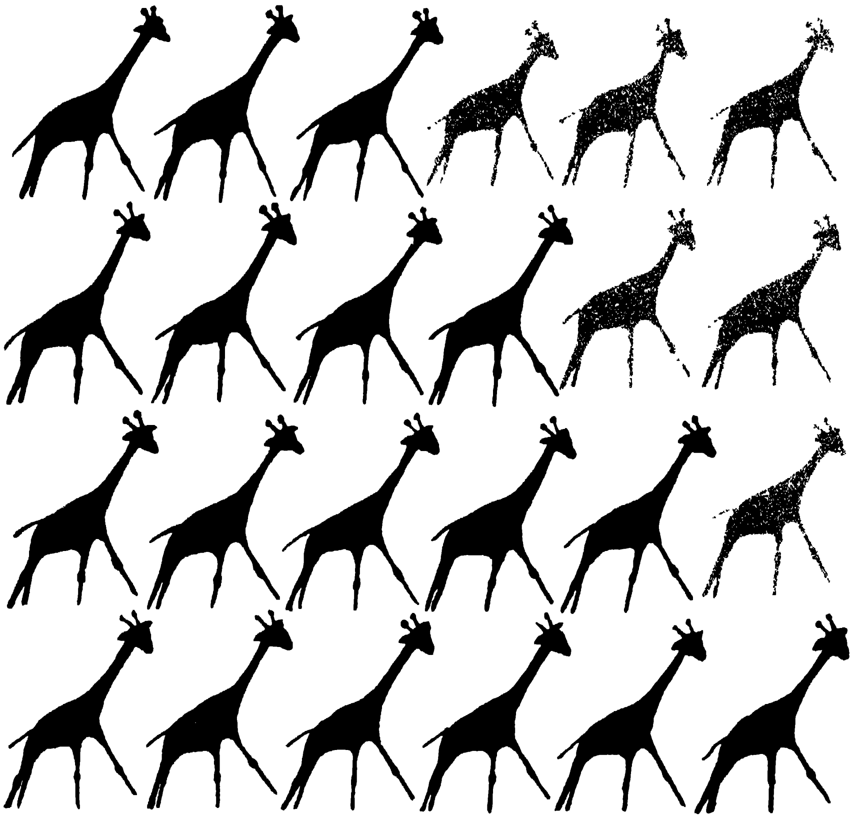
Genes as molecules are discrete. This being so, it is, in principle, possible to compute the genetic constitution of a child from that of its parents. Before doing so, however, a couple of points about genes and their mode of transmission need to be clarified. First, in an individual every gene exists in two copies, which may or may not be identical. Second, any child has an equal probability of receiving each of the two copies of a parent's gene. Consider, for instance, a gene which specifies eye colour. Both copies of this gene might specify blue eyes, in which case the individual indeed has blue eyes. But one of the copies might specify blue and the other, brown; it is then not easy to predict the colour of eyes of the individual. In this particular instance, it turns out that the eyes are brown, and the effect of the genes coding for blue is apparently missing. Here the gene coding for brown eyes (Br) is said to be the *dominant* trait as against the blue eyes alternative (bl). In an individual with two copies, A and B, of a given gene, there is a 50 per cent chance that the child gets a copy of A, or of B. Now suppose the father has copies A, B of a gene coding for a particular trait, and the mother, copies C, D of the same gene. Then the child is equally likely to have one of the possible four alternative pairs: A, C; A, D; B, C; and B, D.

If in a large sample of parents of a genetic make-up as above we had a way of telling the genetic constitution of the children, the prediction is that, on the average, 25 per cent of them would be of each of the four types mentioned above; the types would be in the ratio 1:1:1:1. It is by means of observations of this type, namely a small number of classified types among progeny, and the existence of simple ratios in the actual magnitudes of the types, that biologists starting with Mendel have looked for support to the hypothesis of genes and their role in heredity.

The example of the hygienic honeybees (see box) is a particularly dramatic instance of the genetic control of behaviour. Most of the other cases known are not equally clear-cut.

Genetic effects seem to relate, in particular, to the *intensity* of a behavioural trait rather than to its presence or absence. In such cases it is hardly easy to analyse results in as straightforward a manner as done above. When feasible, one can try to apply selective pressures in the laboratory and attempt to alter the particular behavioural trait under study. In other words, one explicitly tries to induce the behaviour to evolve, and the success of such an attempt is taken as evidence that genes contribute to the behaviour. This sort of approach is, however, limited to a small range of animal species, typically to those that are small and breed rapidly.

In general, however, it is a fairly difficult point to decide whether a behaviour is inherited or not. In most cases a simple yes-or-no criterion for judging the behaviour does not exist, and therefore a degree of sophistication in experimental and statistical analyses becomes necessary. In order to collect a reasonable amount of data, one has to study a large number of individuals who are genetically as like each other as possible. A population which has been inbred for a fairly large number of generations is necessary for this. A comparison of individuals of such an inbred strain with those of another inbred strain of the same species shows how much the variation in behaviour is genetic in origin. A statistical comparison gives an estimate of the extent to which the total variation in behaviour can be ascribed to genetic causes under the particular experimental set-up.



If long neck was a favourable factor to the giraffe, it is possible that long-necked individuals left behind more and more offspring and its less adapted short-necked competitors dwindled away just because they could not cope as well

Obviously, there is an element of faith involved in quantitative extrapolation from the laboratory behaviour of animals to their behaviour in the wild. There seems to be no basis for questioning the hypothesis that there is some genetic basis for much of animal behaviour. The problems, in trying to talk meaningfully about genetic causes of most human behaviour, however, are immense.

Critique

Though the study of animal behaviour and the attempt to explain social behaviour in terms of natural selection has been around for a long time, the present-day critical discussion of this subject has been fuelled to a large extent by the publication in 1975 of the book *Sociobiology: The New Synthesis* by E. O. Wilson. Wilson's book is an encyclopedic attempt at discussing the entire range of social behaviour in animals, and it ends with a section on the possible genetic basis of human sociality.

In so far as the section on humans is concerned, it must be stated that, in trying to build a theory of social behaviour based on sound biology, one cannot do worse at this stage than pick human beings as examples in support of the theory. There are a number of reasons for saying this. To begin with, humans are obviously no good as experimental material in any programme which involves careful breeding and manipulation under rigorously controlled conditions. Next, even if the aim is to attempt to reconstruct *evolution* of human behaviour, it should be remembered that the social and environmental surroundings in which humans live now are probably quite different from those in which their behaviour developed. This means that it is not at all certain that the adaptiveness or otherwise of a present-day behavioural pattern is in any way related to its adaptiveness in the primeval environment.

Another critical fact is that humans are capable of bearing and transmitting learned traits by means of tradition and culture. The most human of human characteristics, the language we speak, meaning the precise set of arbitrary symbols that we use in communication, has certainly not evolved by genetic selection (though the mental and physical *capacities* for speech probably have). However, one must keep an open mind on the question of how human social behaviour came about, and not completely disregard a possible biological basis. Suppose one carries out the exercise and shows that a certain pattern of behaviour is consistent with a genetical explanation, all that one has succeeded in demonstrating is a *correlation* between an assumed set of conditions A and behaviour B. This is because all such exercises incorporate, as part of their basic assumptions, a certain broad environmental set-up which includes certain other aspects of behaviour. In this situation, it goes beyond ordinary reasoning to try and suggest a cause-and-effect relationship between A and B. In fact, one might construct equally plausible arguments to suggest that B is the cause of A.

The genetical theory of natural selection is all-encompassing within its scope; but it does not follow that it provides a useful detailed explanation for any given phenomenon. As an analogy, consider another all-encompassing principle, the second law of thermodynamics, which states that physical systems tend to become less ordered and more disordered in the course of time: it would be futile to study the construction of a watch in an attempt to extract an instance of the working of the second law.

Another general criticism of sociobiological theory that one can make is that its choice of terminology is extremely unfortunate. Words like 'selfishness', 'altruism' and 'spite' in describing animal behaviour call out

[illegible] in India

THE incredibly rich animal life, and the equally fascinating cultural life of India, offers tremendous opportunities to the student of animal and human social behaviour. Most of these problems could be fruitfully approached with nothing more than a paper, pencil and maybe a pair of binoculars. Take, for instance, the primitively social paper-wasps. These insects are poised on the threshold of full division of labour as in an ant nest. But unlike in an ant nest, this division is settled afresh in every colony by a contest amongst them. When studied, these wasps will yield many clues to how social behaviour arose in the great world of social insects.

In Mahabaleshwar, Maharashtra there is a species of insect, the cicadas, of interest to sociobiologists. They begin to call simultaneously by stridulation for 2-3 minutes and stop as suddenly as they began. The noise travels as a sweeping wave over the forest. What is the purpose of this extraordinary display? Wynne-Edwards would probably suggest that it serves to provide an assessment of population density. Alternatively, it may be a territorial display such that the male which fails to call when others do runs the risk of having [illegible]

Then we have our national bird, the peafowl. The peacock's train symbolises the extremes to which sexual selection can derive the display devices of males. This has probably happened through female choice. But we know nothing of female choice in the peafowl. A careful study of the peafowl will throw light on some of the most puzzling problems in the study of sexual selection.

And we have the noisy flocks of babblers — Satbhais or seven sisters — of many species all over our country. Babblers are remarkable in that, not just the parents but often others of the flock also feed the nestlings. The babbler species would therefore offer a wonderful opportunity for shedding light on many questions of how and why blood relatives help each other.

The elephant offers another interesting subject for study—not only in the wild, but in great herds in elephant camps in the forests. It is the only mammal in which the milk glands do not shrink after weaning, but continue to secrete. And the elephant aunts with no babies of their own happily suckle their nephews, nieces and grandchildren. This presents a unique opportunity to study social life in a group of relatives.

And there is a lot of urgent anthro- [illegible] to be undertaken before all the information about the tremendous cultural diversity of the Indian subcontinent disappears for ever. Why was there polyandry with husbands, not related to each other, in Malabar, and husbands, all brothers of each other, in Ladakh? Why was there a system of bride price in some community and of dowry in others? Why were widows treated so badly in some communities and quite well in others? Why were infant girls allowed to die or even killed in some communities? A great deal can be learnt about human social behaviour in the modern perspective from studies in the Indian sub-continent.

But, in spite of the tremendous wealth of material and in spite of the fact that such work needs little by way of sophisticated instrumentation requiring largescale funding, little serious work is being done along these lines. There is hardly any teaching of animal behaviour in Indian universities. It was to try to fill this lacuna that the Tata Institute of Fundamental Research, the Indian Institute of Science and the Ahmednagar College held a two week intensive workshop on "Evolution of Social Behaviour" in Octorber 1979. It is to be hoped that this would stimulate much more activity in this fascinating field in the days to come.

M.G.

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for misuse. The risk in this exercise is precisely that the terms have subjective overtones: rampant confusion can arise between words like selfishness as colloquially used and selfishness meaning a class of behavioural traits coded for in the genes. In particular, considering that the modern theory of kin selection has removed the altruism from the altruistic act, so to speak, one can easily slide into the temptation of suggesting that all human behaviour is selfish (meant colloquially). The danger of falling into a naive genetic determination in trying to explain human behaviour is always there, and this sort of terminology only compounds that danger. It must be acknowledged, however, that at the present stage of its development the genetic theory of social behaviour must stand or fall based on its success in enabling us to gain an insight into the behaviour of other animals.

Table 1.

Simple genetic cross demonstrating the inheritance of genes

UuRr x uurr

Gametes UR Ur uR ur ur

Gametes	UR	Ur	uR	ur
ur	UuRr	Uurr	uuRr	uurr
Genotypes	UuRr	Uurr	uuRr	uurr
Phenotypes	Unhygenic	Do not cap but remove the corpse	Uncap but do not remove the corpse	Hygenic
Proportions	1	[illegible]	[illegible]	1

Let us consider the various possibilities one by one.

(1) *There is no genetic basis for behaviour.* In the light of what we have discussed earlier, this is not true; in fact, the interesting thing is the extent to which single genes can affect behaviour.

(2) *What genetic basis there is, is very weak.* This is a quantitative argument, and hinges on the value of the *heritability* of a trait. Heritability is the technical term for the genetical component of the total variation in a trait. Any measurable individual trait varies from person to person. Part of this variation is due to nurture and environment, part due to the genetic endowment, and a part to interactions between the genes and the environment. The extent of skin pigmentation in humans is an example of a characteristic which exhibits variation due to all three causes. What is crucial for evolution by natural selection is the component of variation which is due to genetic causes; for it is only this variation that makes it possible to distinguish between individuals differing in genetic fitness—fitness that can be passed on to the offspring.

In a study of the mating behaviour in the fruitfly *Drosophila,* the heritability was found to be only 18 per cent. In other words, as much as 82 per cent of the observed variation in behaviour was due to non-genetic causes. It is difficult to counter the thought that if the heritability is so low for what is considered to be a highly stereotyped behaviour in a fly, it is probably lower still for more complex behaviour in higher organisms. The lower the heritability and the longer the time between generations, the longer does it take for evolution by natural selection to occur. To get an idea of the numbers involved, laboratory experiments for evolution in fruitflies with respect to their mating behaviour) typically need about 50 generations for reasonable differences to be observed between strains. It should be emphasised that such experiments involve very strong selective pressures, so that the figure 50 is probably a gross underestimate of the time-scale in nature.

Yet another point to be remembered in connection with the notion of heritability is that it refers only to a particular genotype in a particular environment; one cannot say anything about the heritability of a "trait" in nature from this. There is indeed no hard data on the *extent* to which behaviour in the wild has a genetic basis.

The colosseum in the heart of Rome is a monument to cruelty and sadism. Here men were cast to animals. Gladiators fought fiercely and the loser in a fight was at mercy of the emperor's mood for his life. If the emperor felt like showing a thumb down sign the loser was killed. Cruelty is not found in animals. Cruelty and destructiveness are unique to man and some behaviourists have suggested, in the past, that they were innate to man. How else could one explain man's lack of inhibition against killing, his enjoyment of torturing powerless individuals. Erich Fromm, a psychologist and social philosopher, has another explanation. The basic premise in his theory is that food and shelter are not enough for a man to be happy. Boredom, lack of freedom, inability to realise passions drive him to cruelty

(3) *Alternative explanations may exist for social behaviour.* There are two general classes of alternatives. One is that a particular behaviour has evolved via a maximisation of individual fitness with no regard to kin at all; it just so happens that kin are benefited, say by virtue of their proximity to the individual. One ought to seriously consider this line of thought in, for instance, the problem of social insects and the role of haplodiploidy (Fig. 4). If we consider haplodiploidy and kin selection as the "motive-force" for insect sociality, why are all organisms, with such unusual patterns of inheritance, not social? Further, how is it that the highly social termites have the normal mechanism of inheritance? The sort of alternative explanation which is being suggested here calls for somewhat difficult experiments to be performed; at the least one would have to separate all other influences from the precise social interaction in question and then study the effect on the individual's fitness.

The other explanation is that something like learning is involved, which is heritable all right, but not genetically. The detailed varieties of bird songs within the same species are a case in point. Just like a human language, these songs have different 'dialects' in different geographical locations.

Probably the most spectacular instance of something approximating what we call culture in humans has been found among several island populations of the Japanese macaque monkey. On one particular island, a two-year old female, Imo, started washing sweet potatoes—a new item of diet—by holding it in the water with one hand and brushing sand away with the other. Within ten years, 90 per cent of the troop, all except the very young and the very old males, had acquired this habit. Something more astounding soon followed. Within three years of her earlier invention, the same female Imo invented a sophisticated method for

Female elephants and their calves form a solid phalanx when alarmed. It is this protection of calves which is the glue that binds elephant society together

A pack of wild dogs This highly social predator can bring down prey much larger than itself in size. Only one bitch breeds at a time, and the rest of the pack share in feeding the pups

separating wheat grains, thrown for them on the sand by the researchers. She scooped up the mixture of sand and grains, carried it to the sea, threw it into the water, let the sand sink; and skimmed off the floating grain. Now this tradition spread through the troop as well. Obviously in situations involving group living and where the individuals are capable of learning, it becomes very important to decide to what extent the behaviour is genetically programmed.

(4) *Lastly, the most troubling point of all. The Darwinian theory of natural selection is a historical theory, and by its very nature cannot provide proofs in the way a physical theory is expected*

ly no present-day specie a linear descendant of any other presently surviving species. In fact, it is estimated that over 99 per cent of all species that have ever existed have become extinct, and there are no fossils that depict behaviour. Therefore, it is highly unlikely that by observing behaviour in a given set of living forms one can precisely reconstruct the history of that behaviour, and it is thus impossible to give a detailed evolutionary reason for some specific behavioural trait.

To sum up: any theory of behaviour, and of social behaviour in particular, is beset with problems of testability. These problems are all the more acute for a theory based on genetics and natural selection. If at all a trait is genetically inheritable, it is probably a good bet that natural selection acts on it. At this stage, it seems more appropriate to keep an open mind and try to sharpen methods for testing the theory.

Dr. Nanjundiah obtained his Ph D in physics from the University of Chicago, USA. He has been working at the Centre for Theoretical Studies, Bangalore since 1976. He got interested in the genetics of behaviour and is currently working on slime moulds. He is also interested in pattern formation in biological systems

Recommends reading. 1. A.L. Caplan, (Ed.) *The Sociobiology Debate*, Harper and Row, New York, 1980 2. R. Dawkins, *The Selfish Gene*, Oxford University Press, London, 1976; 3. J R. Krebs and N.B. Davies, *Behavioural Ecology*, Blackwell, Oxford, 1978; 4. M. Sahlins, *The Use and Abuse of Biology*, University of Michigan Press, Ann Arbor, 1976; 5. N. Tinbergen, *Social Behaviour in Animals*, Methuen's, London, 1953; 6. E.O. Wilson, *Sociobiology : The New Synthesis*, Harvard University Press, Cambridge, Mass., 1975.

Genetic control of behaviour

As an example of the genetic control of behaviour, consider the following results of Rothenbuhler on honeybees. Certain honeybee strains are 'hygienic' in the sense that if larva or pupa dies inside a cell in the hive, the workers uncap the seal and remove the dead animal. In 'unhygienic' strains this behaviour does not occur. Among themselves, both of these strains breed true to their type. Hybrids between hygienic and unhygienic strains are all unhygienic. If these hybrids are now mated to hygienic bees, four types of progeny result:

(1) those which uncap cells containing dead larvae, but do not remove the corpses;

(2) those which do not uncap cells, but if the experimenter does so, remove the corpses;

(3) those which neither uncap nor remove the corpse, ie are unhygienic; and

(4) those which can both uncap and remove the corpse, ie are hygienic.

Within the limits of experimental variation, each of these classes occurred in the same proportion. Now we can argue that (a) since among themselves hygienic and unhygienic bees breed true, the trait is heritable; (b) since in hybrids the hygienic trait is not expressed (recessive trait), the unhygienic trait must be dominant to it; and (c) at least two kinds of independent elements, uncapping and removing, are involved in each trait. In symbols, let U stand for the gene responsible for uncapping and R that for removal in the unhygienic bees and u, r, for the recessive genes responsible for the same traits in the hygienic bees. U is dominant to u and R is dominant to r. True breeding implies that unhygienic bees have two copies each of U and R, that is, are U/U, R/R. For similar reasons, the hygienic bees are u/u, r/r. All progeny of these two will be U/u, R/r and therefore unhygienic in their behaviour. Now mating (U/u, R/r) with (u/u, r/r), the possibilities are, in equal proportions, (U/u, R/r): unhygienic; (U/u, r/r): do not uncap, but remove the corpse; (u/u, R/r): uncap, but do not remove the corpse; and (u/u, r/r): hygienic. This genetic cross is depicted in Table 1. The fascinating point is that what seems on first sight to be a complex behavioural pattern can be understood on the basis of the action (or inaction) of just two genes. Another equally striking result is that in this case the effect of each gene seems to be a simple yes-or-no affair.

V.N.

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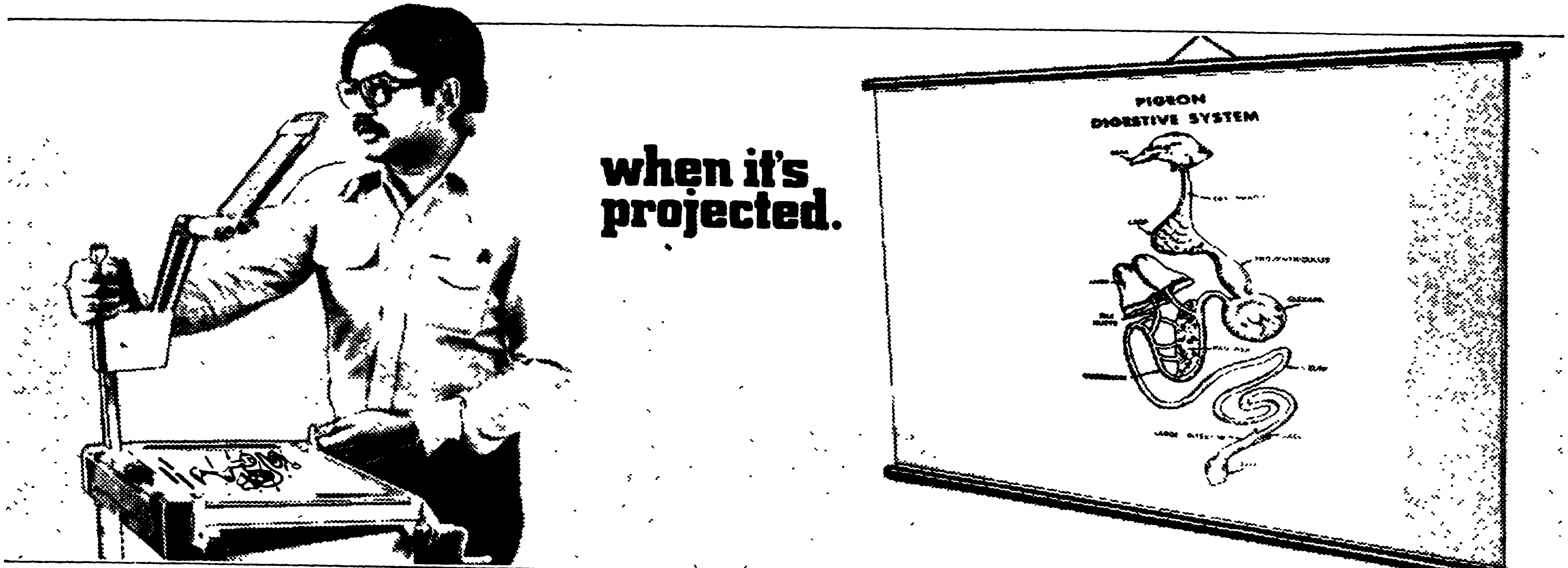

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Preserved foods as cancer hazards

MUCH OF our knowledge of hazards associated with the intake of foods comes from the incidence of a particular type of cancer or sudden outbreaks of certain epidemic diseases in the localised areas of human population, or in the agricultural livestock. Nasopharyngeal carcinoma (NPC), or cancer associated with the upper respiratory tract, has been known to occur in the south China population for more than five decades. Now L.Y.Y. Fong, J.H.C. Ho and D.P. Huang (*International Journal of Cancer* **23** 542) have tried to find out the possible factors responsible for the development of NPC. In the process, they have tested the salted mackerel which is the traditionally preserved and much consumed food item of the local Chinese population.

The authors have used the bacteria *Salmonella typhimurium* as a test system. These have the advantage that they are very sensitive to the chemicals which cause mutations; the results are also indicated in a very short time. In 1973, Professor Bruce Ames had further expanded and testified the validity of the above *Salmonella* test system by coupling it with the mammalian liver microsomes which are the fragments of the endoplasmic reticulum. The microsomes carry most of the enzymes which are responsible for metabolising the exogenous chemicals. In fact, 90 per cent of the chemicals which are known to cause cancer show definite mutagenic activity in this Ames test.

In the above study, extracts of different species of salted fish and dried shrimps were found to be mutagenic in the *Salmonella* test and this mutagenic activity increased substantially with the combination of the microsomes. The salted fish was fed to rats and their urine samples were collected. Mutagenic activity was detected in the urine samples of these rats; the activity decreased markedly when the animals were shifted from salted fish diet to Purina rat chow, which is devoid of salted fish. The authors also state that chronic feeding of rats with salted fish resulted in the development of carcinomas in the nasal cavity and mammary sinus of rats, thus corroborating earlier findings.

Fong and his colleagues believe that intake of salted fish may perhaps be a factor responsible for the development of NPC in the south China population. They fully realise the problems involved in inferring the same results from rats to men. As salted dried fish is consumed in several developing countries, including India, these findings should generate further research.

Also relevant is the recent data about the detection of several mutagens in foods cooked by the conventional and ancient methods. A group of Indian and American researchers (*Mutation Research* **60** 231) have reported the formation of mutagenic compounds in heated beef stock and cooked ground beef. They were also detected by the above *Salmonella* test. Similarly, the presence of mutagenic activity in charred parts of fish, beef and pyrolysates of amino acids and proteins have been convincingly demonstrated earlier by Japanese workers with the Ames test. Some of these mutagenic products have been identified and shown to be strongly mutagenic not only in the *Salmonella* but also in the Chinese hamster cell lines, which may include any of the 14 species of rodents in the family Cricetidae, and human lymphoblasts, which are the precursors of white blood corpuscles. Many flavonoids, a series of widely distributed plant constituents, also exhibit mutagenic activity.

Nothing is, at present, known about the relevance of these observations to humans. But man has been exposed to some levels of mutagenic substances ever since he learned the use of fire. To preserve his genetic heritage, he has also perhaps evolved biological technology consisting of detoxification mechanisms and excretion. He has also developed physiological barriers to cope with the genetic toxicants and to render these chemicals safe. It can also be argued whether the low but lifelong intake of food-borne mutagens is an etiological or a causative factor for some of the spontaneously occurring genetic diseases and cancers in man. These questions will take a long time to be answered. It is not certain whether the present system of assessing health risk to the human population by individual chemicals will be applicable to evaluate a commodity as complex as food.

P S. CHAUHAN

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DNA helix revisited

THE successful crystallisation of DNA in 1938 ushered in an era when X-ray diffraction methods could be used for the elucidation of its structure. Since then intense research has gone in the X-ray diffraction studies of DNA. The first breakthrough in the structure-elucidation of DNA, however, came from Crick and Watson at Cambridge, in 1953. The validity of their double-helix model was checked with the available X-ray diffraction pattern of B-DNA. The model was simple and stunning. The base-pairing implied that when one strand of DNA is specified, the other strand is automatically specified as its complement. The model gave new insight into the replication of the gene.

But, ever since its inception, this theory has been criticised on various grounds. Watson and Crick themselves had a few forebodings regarding the process of unwinding of the regular right-handed double helix into the complementary chains prior to replication. The two chains must at least be partially unwound to allow replication to occur, since the bases, whose sequence carries the genetic information, are located within the parent double helix. Such unwinding would generate torque in the DNA. The unwinding should also be extremely rapid as, for instance, the entire chromosome of *E.coli* is replicated in a single division time of 30 minutes. Some 400,000 turns of the double helical chromosome must be unwound, at a rate of at least 13,000 per minute, comparable to the spin rate of a high-speed centrifuge. No wonder the unwinding riddle has attracted the attention of scientists.

V. Sasisekharan and his colleagues at Bangalore, India, and G.A. Rodley and colleagues in New Zealand, made the first dent in the Watson-Crick double helical structure of DNA around 1976. They addressed themselves to the unwinding problem of DNA and arrived at a structure of the B-DNA, radically different from the Watson-Crick model but conforming to the diffraction pattern of B-DNA. They also used model-building as the primary mode of structure elucidation and arrived at a DNA duplex structure. They questioned the validity of the right-handed double helix and instead proposed, independently, alternating right-and-left-handed helices, arranged side by side, forming the DNA duplex kept together by Watson-Crick base-pairing. This structure has been variously known as the side-by-side helix, as the two strands do not intertwine each other, or the right-left helix (RL helix). Each of the strands of this DNA duplex has about five base-pairs in right-handed helix alternating with about five base-pairs in left-handed helix, giving 10 base-pairs in this repeat. Depending on the orientation of the sugar rings in the backbone, they defined two possible alternate arrangements for the duplex.

The advantage of the side-by-side helix during unwinding is immediately obvious. It is needed only to break the hydrogen bonds between the Watson-Crick base-pairs; the chains will start to fall apart without twining around each other. The model could also explain the supercoiling observed in eukaryotic chromosomes, as a natural consequence of their following a supercoiling path with about 100 base-pairs forming one turn of this supercoil and giving a pitch of 100 Angstroms. The supercoiling in the double helix could be explained only by kinks in the otherwise regular helix, as proposed by A.G. Klug and F.M. Crick at Cambridge.

V. Sasisekharan and G. Gupta in a recent article (*Current Science* **49** 43) have

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investigated the effect of different conformations of the bases on their DNA duplex structure. They have arrived at two topologically distinct types of duplexes, the uniform helix and the zigzag helix. As the names indicate, the uniform helix has a uniform helical twist and vertical displacement of the successive phosphate groups, while in the zigzag helix the phosphate groups go around the helix axis in a non-uniform or zigzag fashion. As they combined the allowed conformations of the sugar in the backbone with those known for the bases, they found that the purines in the anti-conformation produced right-handed helices and the purines in the syn-conformation produced left-handed uniform or zigzag helices.

Along with the theoretical model-building studies, various groups of workers have tried to get good quality crystals of at least fragments of DNA and polynucleotides, to get their accurate structure by X-ray diffraction analysis. Recently, A. Rich's group at Massachusetts Institute of Technology, USA, has elucidated the exact molecular structure of a fragment of DNA at atomic resolution (*Nature* **282** 680). For the first time a left-handed double helix with Watson-Crick base-pairing and an antiparallel organisation of the sugar phosphate backbone has been revealed beyond doubt. The helix is zigzag in its backbone—a left-handed double helix and not a side-by-side helix. It is interesting that the purines in this zigzag left-handed helix are in the syn-conformation as in the theoretical models of Sasisekharan and Gupta. Rich and colleagues have also examined the possibility of this new form of zigzag left-handed double helix DNA, or Z-DNA as they name it, occurring along with the right-handed double helical B-DNA This alternating right-and-left-handed double helix will, however, have a change in the regularity of the base-pair stacking when the B-DNA goes over Z-DNA and vice versa. As has been pointed out by Rich and colleagues, this model they have proposed is not the same as the RL model of Sasisekharan or Rodley.

K.K KANNAN

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Primordial intergalactic clouds

Astronomers have recently discovered yet another evidence in favour of the big bang model of the universe. Observations of the spectra of very distant quasars by British and American astronomers have revealed the presence in intervening space of clouds of pure hydrogen and helium without any trace of heavy elements like carbon, oxygen, etc. These clouds could be the remnants of the big bang that created the universe.

Since the discovery of the microwave background radiation, the big bang model has emerged as the most favoured theory of the origin of the universe. According to this model, there was a stupendous explosion of energy from a superdense compact state several billion years ago. The energy, in the form of radiation, and matter, cooled as the universe expanded and, after sometime, the equilibrium between matter and radiation came to an end; then onwards, matter cooled differently from radiation. The remnant radiation is what is now observed as the microwave background radiation (Science Today, January 1980, p.25). The matter underwent nuclear transformations, resulting in the formation of deuterium and helium. These elements, partaking in the expansion and cooling of matter, clumped together after a few billion years to form clouds and galaxies. These clouds are drifting in the intergalactic medium as wanderers; the matter in the galaxies underwent star formation. The heavier nuclei were synthesised in these stars and, when the stars exploded, thrown in the interstellar medium within the galaxies.

Since every element has a characteristic spectral feature, it is easy to tell the presence or absence in distant space of elements which are normally prominent. So, while analysing the spectra of distant quasars, W. Sargent and P. Young from Caltech, USA, and A. Boksenberg and D. Tytler from University College, London, were surprised to find a total absence of any spectral features due to carbon, oxygen or iron in the intervening clouds. As the nearby intergalactic medium will certainly be contaminated by these elements, the only conclusion that can be drawn is that these clouds are very distant, so far away that stellar nucleosynthesis has not affected them. These can only be the remnants of the big bang. The report of this study will shortly appear in the *Astrophysical Journal*, USA.

Of course, interpretation of quasar spectra is always beset with difficulties. In order to put the evidence on a firm footing, it is necessary to further study the radiation patterns of the clouds and quasars. These studies will tell us about the early days of the universe and perhaps give us clues as to how the universe will end.

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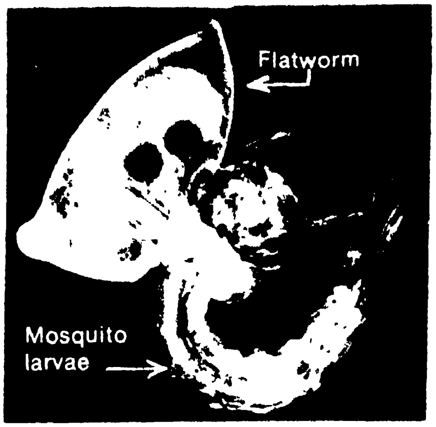
Flatworm control of mosquito larvae

Recently, biological control of vector species, a kind of natural control which does not involve environmental pollution and hazards, has gained considerable importance over the conventional, chemical insecticide method of control. This may be achieved through microbial agencies using bacteria, viruses, fungi, protozoa or nematodes; by using predaceous mosquitoes of *Toxorhynchitis* genus or predaceous fishes like *Gambusia, Tilapia* or *Poecilia;* through the use of juvenile hormone mimics, which are known as third generation pesticides; by genetic manipulations, where cytoplasmic incompatibility is brought about; and by replacement of native vector species with non-vector strains. These methods gained ground because of the resurgence of resistant vector species, which led in turn to the upsurge of diseases like malaria and encephalitis.

T.J. Case and R.K. Washino (*Science* **206** 1412) while dealing with the type of biological control of mosquito larvae show that there is a positive correlation between the presence of flatworms and low population densities of mosquito larvae of *Culex tarsalis* in rice fields. They have confirmed their field observations in the laboratory by microscopic studies and shown that the presence of flatworms of genus *Mesostoma* are responsible for this phenomenon. The flatworms can parasitise and kill a larger number of larvae than they can consume as their prey within a particular time interval.



The touch of death — Seen above is the larva of *Culex tarsalis* in contact with the flatworm, *Mesostoma*. This contact has a paralysing and ultimately fatal effect on the insect.

Legenerand Legner and his colleagues (*Mosquito News* 1977) had shown the efficacy of yet another biological agent, a flatworm *Dugesis dorotocephala* (a non-cannibalistic strain of a planarian) in the control of Culicine mosquito larvae. However, the present authors score a point over Legner, in which they have proved that this flatworm has an ability to overwinter in rice fields. When once established, this worm could propagate itself and regulate the vector species population which is a character of great advantage. This biological control agent, when fully exploited, may prove of immense value in controlling the mosquito larval population, especially in rice fields.

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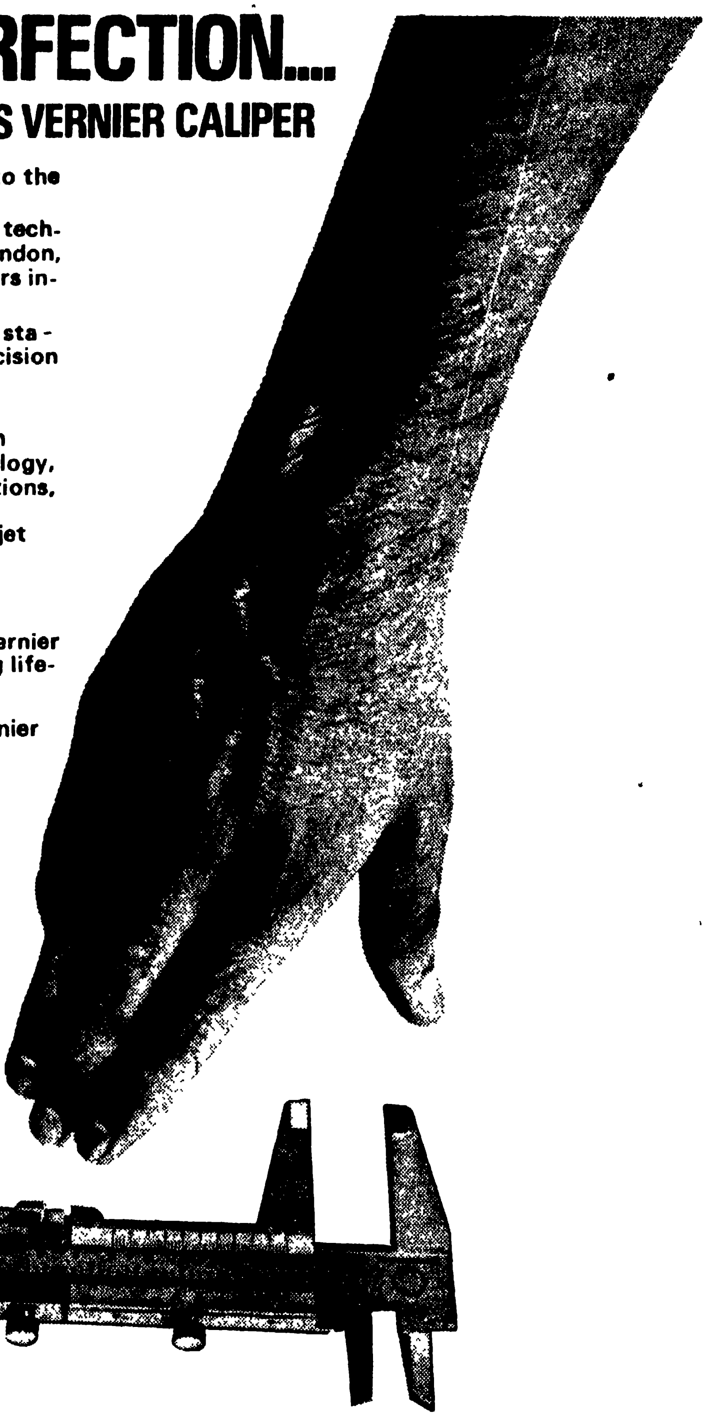

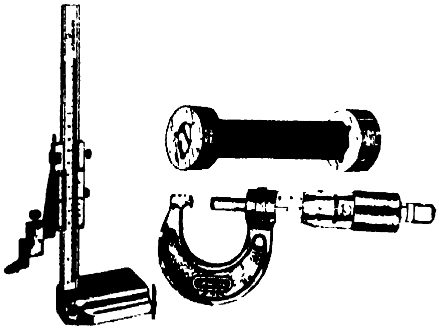

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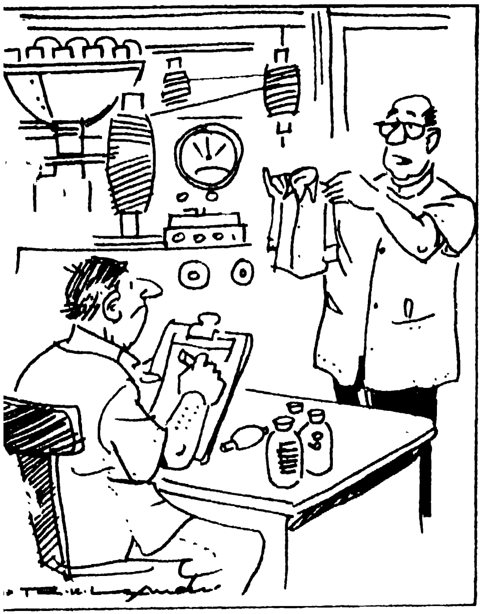
"As obstinate as ever he still does not believe in life after death."

This World of Science!

by R.K. Laxman



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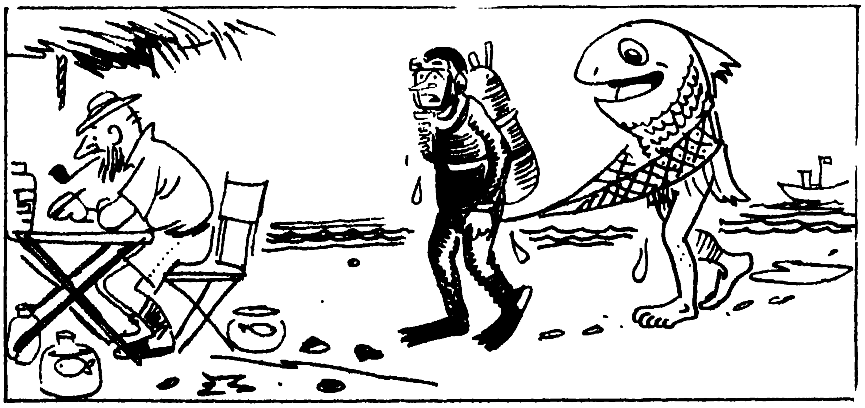
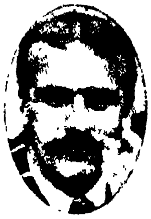


"I am afraid our investigations into the existence of mermaids has proved a bit of a disappointment, doctor."

In Lighter Moments

In Lighter Moments



Haldane

An artist reveals himself in his creations...

Once some churchmen, trying to tease J.B.S. Haldane about his atheism, asked him whether he had any idea of the nature of the Creator, as evidenced by His creations.

"An inordinate fondness for beetles," replied the biologist. He went on to explain, "Insects, you see, have the most numerous species, and among insects, the species of beetles are more numerous than others."

*

The eminent English surgeon, James Simpson was very indifferent, even careless, in money matters. Once while he was sleeping, his bedroom window rattled, which caused him much irritation. He got up, took a piece of paper from the sofa by his bedside and stuffed the window-sill chink with it.

The next morning his wife discovered that this piece of paper was a £ 10 note.

*

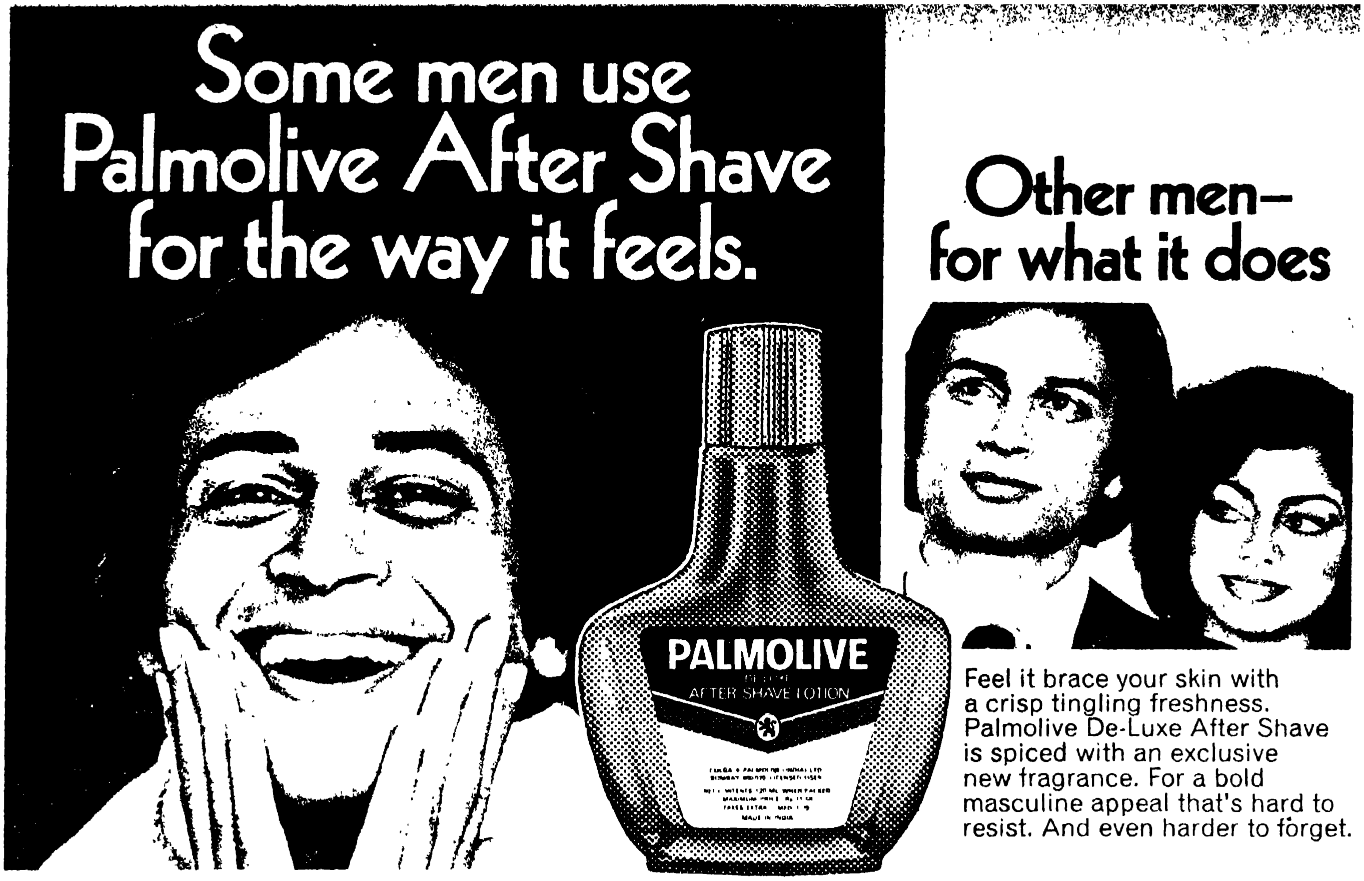
Huxley

During the Second World War, the BBC used to broadcast parts of the *Animal Language*, jointly written by Julian Huxely and one Ludwig Koch of Germany. It was "a talking book" presented to the listeners with such sounds as the wolves' chorus at Whipsnade (where Julian lived), the bird-like chatter of the panda, the grunts of camels, the explosive grunts of the gnu, and the extraordinary outbursts of the hyaena's laughter."

*

Even the most ardent Darwinists fail to understand their mentor's lapse in his assessment of his own contemporary, Lamarck's version of evolution. We find Darwin writing to Hooker in 1844: "Heaven defend me from Lamarck's nonsense of a 'tendency to progression'." This despite Darwin's belief in 'the inheritance of certain 'acquired characters'. And strangely, this belief was given much more importance in the *Origin's* later editions, though without giving credit to Lamarck.

S. N. MUNSHI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A new synthesis of aldehydes and ketones

ALDEHYDES and ketones occur widely in nature. They play a major role in biological processes. An important group of the naturally occurring ketones is the hormones with the complex structure characteristic of sterols. Testosterone and cortisone are a few such compounds. Other naturally occurring ketones of importance are muscone, irone, etc used in the perfume industry.

Of the various methods of preparing aldehydes and ketones, a simple one consists of oxidation of methyl or methylene groups. In one procedure, chromyl chloride is used as the oxidising agent (Etard method) for conversion of the methyl side-chain into aldehyde. Chromic anhydride in acetic anhydride is useful to arrest oxidation at the aldehydic stage. This is probably due to the formation of aldehyde diacetate, which can prevent oxidation from going too far. But the problem is that oxidation of methyl to an aldehyde is unsuccessful when other easily oxidisable groups are present. Besides, yields are not satisfactory, and acids are also produced along with the aldehydes; different products are formed with other oxidising agents. For making phenol, cumene (isopropylbenzene) peroxidation is the leading process (*Chemical Engineering*, International News **54C** 62, 1970).

Selenium dioxide is also used for oxidising the methyl and the methylene groups attached to the carbonyl group. The reagent converts acetophenone into phenylglyoxal by means of an equimolecular quantity of selenium dioxide in boiling dioxane. Conversion yields are always safisfactory. Usually, it varies from 70 to 80 per cent or more except in some cases; for phenylglyoxal the yield is 72 per cent, whereas, for benzil from desoxybenzoin, it is 88 per cent. Though the use of selenium compounds as oxidants is not unknown, conversion of benzylic hydrocarbons into aldehydes and ketones is of recent origin (*Tetrahedron letters* **35** 3331, 1979). The investigation revealed that benzylic hydrocarbons can be oxidised to aldehydes and ketones with benzene-seleninic anhydride.

D. H. R. Barton and his collaborators indicated that the method is general. Aldehydes and ketones can be obtained by oxidation of the methyl and the methylene groups attached to the aromatic ring. Thus, from toluene, benzaldehyde is produced, but from diphenylmethane benzophenone is obtained; from ethylbenzene, acetophenone is produced. Both acetophenone and benzophenone, which have varied uses, are obtained by oxidation of the methylene group. The difference with selenium dioxide is that, oxidation with the anhydride does not require the methyl or the methylene group to be attached to the ketonic group as in acetophenone and desoxybenzoin.

The investigators found that camphor yields camphor-quinone and 9, 10-dimethylanthracene anthraquinone and

hat the yields are always satisfactory. However, when the electron-attracting groups such as the nitro group is present as in *P*-nitro-toluene, oxidation with anhydride does not occur. When, however, donor groups, like the methoxy group, are present, the yields are also poor. With *P*-methoxytoluene, the major product is 2-phenylseleno-4-methylanisole.

It is essential to avoid the excess use of anhydride. The investigators had shown that with 0.33 mol equivalent anhydride at 132°C on xylenes *(ortho-, meta-, para-)*, the major products are the corresponding monoaldehydes and the yield of the acid is very poor. The yield increases on using excess anhydride. The new method is useful for preparing ketones and aldehydes which are difficult to prepare by hitherto known methods.

P. C. BHATTACHARYYA

Dr. Bhattacharyya teaches chemistry in Vidyasagar College, Calcutta.

Corrections

In "Radiosonde Thermistor" (Ideas & Inventions, December 1979) the figure, 10, was missed on the Y axis of the resistance-temperature graph. The figure, 50, which appeared in its place, should have appeared just below "100". The resistance of the thermistor at 30° C is 14 kilo-ohms.

The name of the second author of "Piezoelectric devices for precision movement" (Ideas & Inventions, February 1980) should read as Mukesh Chandra (not Mahesh Chandra, as printed). —Ed.

Brain Teasers Brain Teasers Brain Teasers Brain Teasers Brain Teasers Brain

Medium of instruction:

I was to teach textile chemistry to applied art students in an arts college. The question arose whether I should teach the class in English or in Hindi. I told them to decide by voting. The results showed that the English-protagonists won by exactly half the number of Hindi protagonists. After some time, six from the group that voted for English said that they did not understand the issue of voting (since they did not understand English well) and asked for a re-poll. I agreed. Now the Hindi protagonists won by three votes and I started teaching in Hindi.

How many students were there in the class?

V.A. SHENAI

Solution next month)

Solution to last month's Brain Teaser

The Kite Flier

Let x be the red kites at x paise and y be the blue kites at y paise.
So the total cost = $x^3 + y^2$ which is less than 500 paise (given).

Now $x^2 - y^2 = 93$

Or $(x + y)(x - y) = 93 \times 1$ or 31×3.

So $x + y = 93$ or 31
and $x - y = 1$ or 3
So $2x = 94$ or 34
or $x = 47$ or 17

In the same way,

$2y = 92$ or 28
or $y = 46$ or 14
Therefore $x = 47$ and $y = 46$
or $x = 17$ and $y = 14$
However, as $x^2 + y^2 < 500$, $x = 47$ and $y = 46$ could not apply,
So, here $x = 17$ and $y = 14$

Dr. Shenai writes:

REGARDING the solution published in SCIENCE TODAY (February 1980) for the Brain Teaser, "Landlords and Tenants" (January 1980), Dr. S.D. Vaidya, a friend of mine, has sent an alternative solution, which also satisfies all the conditions given in the brain teaser. In Dr. Vaidya's solution, the old and the new owners of Ashok Mahal and Arun Mahal remain the same as in mine, while the owners (old and new) of Balaji Mahal and Sunder Mahal get exchanged.

"Lottery win": An error has crept into the solution (December 1979). The last two lines should read:

"This makes X = 19 and Z = 80, and hence Y = 1".

The error is regretted. - Ed.

Uttarpara

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Towards a 'Grand Unification'

Virendra Singh

Madame Curie with Robert Millikan Early studies laid not only strong foundations, but set a lasting trend

What started with Newton, Faraday and Maxwell continues with Glashow, Weinberg and Salam. This second part of the article on basic forces and their unification describes how the forces in physics are continuing to take on more intriguing conceptual forms

ANTOINE HENRI Becquerel in 1896 discovered an entirely new phenomenon which was neither gravitational nor electromagnetic in origin, but rather a manifestation of a totally different interaction, now called the weak interaction. This was the phenomenon of radioactivity. Stimulated by the discovery of x-rays and of the rays emitted by the phosphorescent walls of the Crooke's tube, Becquerel wondered whether other phosphorescent materials would also emit similar rays. He tried double phosphate of uranium and potassium and found that some rays which blacken photographic plates were indeed emitted.

Two years later, E. Rutherford established that there were at least two components in the Becquerel rays. One of these, named alpha, was absorbed by matter readily while the other, named beta, "was of a more penetrating character". It was soon established that beta rays consist of a stream of electrons. Meanwhile, electrons had been identified through the experiments of E. Wiechart and J.J. Thomson (1897) as the universal electrically charged constituents of all atoms. "Assuming that they carry the fundamental unit of electric charge..." their mass was determined by Thomson to be about 1/1800th that of hydrogen, the lightest atom.

Very soon (1898) Madame Curie's experiments established that the amount of radioactivity was proportional to the amount of radioactive material. Apart from uranium salts, many other materials, too, were found to be radioactive. After the discovery of the atomic nucleus by E. Rutherford in his classic alpha-scattering experiment, the fact of radioactivity as a nuclear process was realised by Neils Bohr.

James Chadwick, in 1914, noticed a very puzzling feature in the energy spectrum of these electrons coming out in the beta-radioactivity process. The electrons were not of the same energy; they had a continuous distribution in energy with a cut-off on their maximum energy. Now, if the basic process in beta-radioactivity is the transformation of a radioactive nucleus into another with the emission of an electron, then all the emitted electrons must have the same energy if the energy-momentum conservation law is valid. Surely, this failure of the conservation law, which had emerged as a cardinal principle of physics with universal applicability, must only be apparent. A possibility that was seriously entertained in this connection was that some gamma rays—electromagnetic radiation of high frequency—were also being emitted along with electrons. This possibility was ruled out, for in the beta decay of radium E no gamma rays were seen. Clearly, an impasse had been reached.

Neutrinos and neutrons

The way out was suggested by Wolfgang Pauli in a communication, addressed to a conference at Tubingen, W. Germany, dated 4 December 1930, wherein he said, "I have hit on a desperate remedy to save the law of conservation. This is the possibility that electrically neutral particles exist, which I shall call neutrons which... have a spin ½ and obey the (Pauli's) exclusion principle... The mass of the neutrons should be of the same order as those of the electrons... The continuous beta spectrum would then be understable if one assumes that with each electron a neutron is emitted during beta decay in such a way that the sum of the energies of the neutron and electron is constant."

These particles postulated by Pauli were renamed by Enrico Fermi as neutrino ("the little one") and were first directly observed only in 1956 by F. Reines and C.L. Cowan Jr. This was done to distinguish them from another subatomic particle called the "neutron", discovered by J. Chadwick in 1932. The term neutron is now used only for the Chadwick's neutron. The neutrons are also electrically neutral, like the neutrinos, but were found to be much more massive. The mass of the neutron is slightly more than the sum of the masses of a proton (hydrogen nucleus) and an electron. Today, neutrinos are regarded as massless, just like the photons

The discovery of neutrons by Chadwick was essential to understand

When Wolfgang Pauli observed some energy and momentum missing when a beta particle was emitted from an atomic nucleus—a grave violation of the conservation laws—he postulated a new particle rather than question the conservation laws. Enrico Fermi later named the particle as 'neutrino'

Hideki Yukawa was the founder of the meson theory of nuclear forces

the nuclear structure. Previously, it was natural to imagine various nuclei as consisting of an appropriate number of protons and electrons, On a first consideration, the presence of electrons inside nuclei was indicated by the phenomenon of beta-radioactivity where electrons are emitted by the decaying nuclei. Except for very brief instants, this is, however, ruled out by quantum mechanics.

The nuclear radii are very small and are of the order of 10^{-14}m. The electrons, when confined to such a small region as a nuclear volume, would acquire enormous momentum due to the uncertainty relation and would thus escape from the nucleus. Since these relativistic electrons would possess velocities close to that of light, they would take a very small time—of the order of 10^{-22} seconds. Thus, electrons cannot exist inside stable nuclei, and, further, since these time scales are much too small compared to the lifetimes of beta-decaying nuclei, they cannot exist even inside these radioactive nuclei. In view of this, and other difficulties, Karl Werner Heisenberg, in 1932, proposed that the nucleus of an atom, with atomic weight A and atomic number Z, consists of (A-Z) neutrons and Z protons. Since then, this has been the cornerstone of the entire world of nuclear physics. This together with Pauli's neutrino hypothesis were the two main ingredients utilised by Fermi, in 1933, to give a theory of the beta decay of the nuclei.

Fermi's theory

As we have seen, no electrons are present in the nuclei. Where, then, do the electrons in the beta decay come from? According to the quantum theory of electromagnetic radiation, the emission of a photon from an atom is a spontaneous process. Fermi, by analogy, postulated that an electron-antineutrino pair is similarly produced spontaneously at the moment of emission in the beta decay process. Taking the analogy further, an electron-antineutrino pair was taken to be produced in a state of angular momentum equal to that of a photon, that is one (in units of $h/2\pi$ where h is Planck's constant). The basic process was taken to be the transformation of a neutron-antiproton pair with unit angular momentum to an electron-antineutrino pair with the same angular momentum. Since objects with angular momentum one, of the type seen in an electromagnetic field, are called vectors, Fermi's theory was a vector theory of weak interactions. All the particles involved in these pairs obey Pauli's exclusion principle and are thus fermions. The theory is therefore also referred to as the "four fermion theory", since two pairs of fermions are needed.

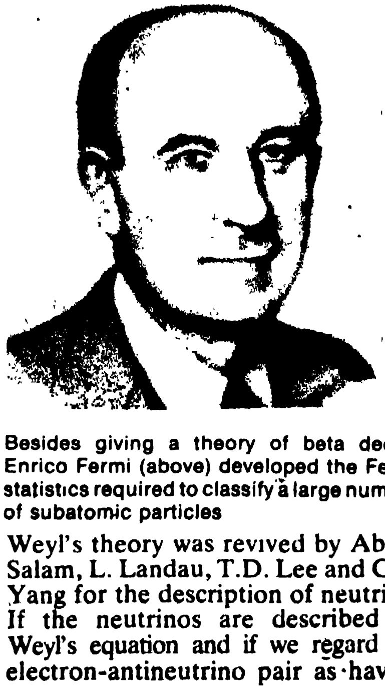
What is the range and strength of this new interaction? Fermi took the interaction to be a contact interaction—one where an electron-antineutrino pair was produced at the same space-time point at which the neutrino-antiproton pair was annihilated. The range was thus taken to be zero. Present evidence points to a probable range of 10^{-16} cm. This is quite in contrast to the electromagnetic and gravitational interactions where the range is infinite. To account for the observed lifetimes of the beta-decaying nuclei, it was found that the strength of weak interactions must be about a thousand times weaker than those of electromagnetic interactions, thus justifying the appellation "weak interaction".

Fermi's theory was later elaborated in many ways to account for further weak interaction phenomena discovered later. Carl D. Anderson and S.H. Neddermeyer had, in 1936, discovered a new particle now known as the muon in cosmic rays, which had a mass about 200 times that of the electron, but with the same electric charge. The phenomenon of muon decay could be accounted for by adding another pair—the muon-antineutrino—to the Fermi's scheme. The strength of the interaction bringing about transformation between any of these three pairs—neutron-antiproton, electron-antineutrino and muon-antineutrino—was found to be essentially the same. That led to the hypothesis (1948-49) of a universal four-fermi interaction. Note that for all these three pairs, the electric charge carried by them is -1e. They are thus electric-charge carrying currents. In contrast, in electromagnetism, the pairs involved are electron-antielectron, proton-antielectron, proton-antiproton, etc, the pairs carrying no electric-charge and thus involving neutral electromagnetic currents.

A major aspect of weak interactions, that its laws—unlike those of gravitation and electromagnetism—do not remain unchanged under the operation of space-reversal, was discovered in the late 1950s. Around that time two particles, called theta and tau, were discovered in cosmic rays. These had the same mass, the same lifetimes (of the order of 10^{-8} sec), and the same production rates in nuclear reactions. They, however, had different decay modes: the theta decayed into two pions while the tau decayed into three pions. A natural conclusion would have been that theta and tau are really one and the same particle seen in two different decay modes. Such an assumption, however, was inconsistent with the invariance of laws responsible for decay under space reversal operation. The interaction responsible for decay here, in view of the lifetime mentioned above, is the weak interaction. In 1956, T.D. Lee and C.N. Yang, therefore, made a critical examination of the evidence for space-reversal invariance in physics and suggested that weak interactions did indeed violate it.

V-A theory

Clearly, a necessary modification of the Fermi theory to incorporate this non-invariance was needed. An important role here was played by a theory of massless spin ½ particles proposed by Hermann Weyl, in 1929, in which the spin of the particle was always parallel (and that of its antiparticle always antiparallel) to its momentum. This theory was rejected by Pauli on the grounds of its space-reversal non-invariance. But, now, with the discovery of non-variance, Weyl's theory was revived by Abdus Salam, L. Landau, T.D. Lee and C.N. Yang for the description of neutrino. If the neutrinos are described by Weyl's equation and if we regard the electron-antineutrino pair as having unit angular momentum, then the space-time structure of the pair is



Besides giving a theory of beta decay, Enrico Fermi (above) developed the Fermi statistics required to classify a large number of subatomic particles completely fixed. It is a specified mixture of a vector (V) and an axial vector (A) which, in standard convention, reads like V-A. An elegant solution was found by E.C.G. Sudarshan and given in his doctoral thesis written under the guidance of R.E. Marshak in 1957 and a little later by R. P. Feynman and M. Gell-Mann. The proposal was to have the same space-time structure for the other pairs, such as the neutron-antineutrino pair.

In 1962 it was discovered by a Columbia University group that neutrinos come in two varieties, now referred to as electron-type neutrino and muon-type neutrino. The previous description of the interaction theory is to be modified by having the electron (muon) being associated with the antineutrino of the electron (muon) type. Thus the muon is basically different from electron, and is not just a heavier electron, in that it carries a new type of charge—mu-ness. The mu-ness is conserved in reactions. The electron has zero mu-ness. Similarly, the electron and its neutrino carry an electron-ness which is zero for a muon and its neutrino. The proton and neutron carry zero electron-ness and mu-ness.

Nuclear force

Having seen that the nucleus is composed of neutrons and protons, you might wonder what keeps them together. Gravitation and the weak interaction are just too small for that. Again, electromagnetic forces between two protons can only cause repulsion, while between a neutron and a proton, or between two neutrons, there could be nothing that matters since neutrons are electrically neutral. Therefore, we have to postulate a new force to operate between nucleons, the constituents of atomic nuclei. But what is the nature of this nuclear force?

In 1927, F.W. Aston measured the masses of a large number of atoms. These were found to be very close to integral multiples of the mass of the proton and the difference — mass defect — was found to be essentially proportional to their mass number (total number of nucleons). In view of the energy-mass equivalence, the binding energy was thus seen as proportional to the mass number.

Besides, on the basis of scanty information available from the scattering of alpha particles (helium nuclei from the nuclei of other atoms) it was proposed (1929) by G.Gamow that the mass density of various nuclei is essentially the same. As noted by E. Majorana in 1933, "It looks as though nuclei consist of rather independent components which react only on immediate contact, that is, some sort of matter with the same properties of size and impenetrability as macroscopic matter. Light and heavy nuclei are built up of this matter and the difference between them depends mainly on their different content of 'nuclear matter'. This theory can only be correct if the coulomb repulsion between the positive components of nuclei is neglected. If we assume that nuclei consist of protons and neutrons, we have to formulate the simplest law of interaction between them which will lead, if the electrostatic repulsion is negligible, to a constant density of matter. We have to find three laws of interaction: one between protons, one between protons and neutrons, and one between neutrons.

"Nuclear structure and the structure of solids and liquids seem to be somewhat similar and it might be possible to have an interaction of the same type as between atoms and molecules. That is, attraction for large distances and strong repulsion for small distances so that the particles do not penetrate each other."

Behind the jargon

Antiparticle: The equations describing the quantum theory indicate that for each particle there must be a corresponding antiparticle with the same mass, spin, and mean life, but with opposite charge (in the case of charged particles) and opposite magnetic moment. When a particle and its antiparticle interact, they may be annihilated with a release of energy.

Asymptotic freedom: The property of some gauge theories of strong interactions—that strong interactions grow steadily weaker at high energy.

Bubble chamber: A device that detects charged particle by producing bubbles along the path of the particle through a superheated liquid.

Interactions: There are four primary types of interactions in nature: (1) Strong interactions, which are manifested by the force that holds the nucleus together. They are characterised by their short range($\sim 10^{-13}$cm) and their great strength. (2) Electromagnetic interactions, the interactions of charged particles with electromagnetic fields. (3) Weak interactions, which are short-range interactions, many orders of magnitude weaker than either the strong or electromagnetic ones. (4) Gravitational interactions are the weakest of the four. They depend on the masses of the bodies involved and result in the mutual attraction of all bodies.

Meson: Particles with masses greater than the electron mass and less than the mass of a nucleon are called mesons. Included in this group are the *K* meson (or kaon), the μ meson (or muon) and the π meson (or pion), and many others.

Parity: According to the parity principle, a 'mirror image" of a physical process depicts a possible physical process obeying the same laws as the original one. It has been experimentally shown that the principle holds (namely, that parity is conserved) for strong interactions, but not for weak interactions.

Spin: A quantum number characterising a particle, which must be included when describing the total angular momentum of elementary particles or nuclei.

Chen Ning Yang (above) along with T.D. Lee, studied the evidence for parity conservation. They showed that there could be violations of space reversal symmetry. Substantial advance followed

An idea of the strength of the nuclear forces can be obtained by comparing typical energies involved. The binding energy per nucleon for a nucleus is approximately 8 MeV, while the binding energy of the hydrogen atom in its ground state, arising from electromagnetic interactions, is just 13.5 eV. Taking into account the difference between nuclear and atomic dimensions, these forces turn out to about a hundred times stronger than the electromagnetic force at distances of the order of one fermi (10^{-15}m), thus justifying their name, "strong interactions". Their range is, however, very small — of the order of one fermi — and thus these strong forces are negligible outside nuclear distances.

Yukawa's theory

H. Yukawa proposed in 1935 that the nuclear force between a neutron and proton resulted from the exchange of massive particles between neutrons and protons. This was analogous to Dirac's theory where the electromagnetic interaction between the charges arises due to exchange of massless photons which are the particle aspect of electromagnetic field in quantum theory. In order to account for the short range of the nuclear force, Yukawa obtained a mass of around 200 electron masses for his massive postulated particles. Heisenberg had already emphasised the importance of charge exchange between neutrons and protons in his theory of nuclear force. Yukawa retained this feature in his theory. Thus, a neutron, by emitting negatively charged massive quanta could convert itself to a proton and by emitting positively charged massive quanta could become a neutron (Fig.1). Further, these quanta had to have integral spin and conform to Bose statistics.

In those days, the introduction of an unknown new particle was a daring thing — a fact which explains why Pauli never published his neutrino suggestion. As such, Yukawa's theory did not initially get much recognition. The discovery of the muons in cosmic rays, with masses around 200 electron masses, brought Yukawa's ideas to the fore. The muons, however, were found to have only feeble interaction with matter and thus were not the particles predicted by Yukawa, which ought to have interacted strongly with matter. But the Yukawa particle was at last discovered in 1947 by C.F. Powell and co-workers using nuclear emulsions, a new technique. They are now known as pions and have a mass of about 276 electron masses (or about 140 MeV, in energy units). The muons are a decay product of the pions.

Another remarkable feature of nuclear forces, now referred to as "charge independence", was discovered by G.Breit, E.U. Condon and R.D. Present, in 1936, when they compared the low energy scattering data on neutron-proton and proton-proton scattering. They found that, apart from the coulomb force between two protons, the purely nuclear force between a neutron and a proton or between two protons, when they are in the same space and spin configuration, is equal. Thus, nuclear force does not depend on the electric charge of the nucleon and should be the same between two neutrons. Note that the nuclear forces, unlike the gravitational and the electromagnetic, are strongly dependent on space and spin configuration.

It was pointed out by N. Kemmer, in 1938, that if Yukawa's theory has to have "charge independence", then, apart from charged pions, there should also exist neutral pions with roughly the same mass so as to mediate nuclear force between two neutrons or two protons. These have also been discovered (1950).

In view of the charge independence, it is natural to regard neutrons and protons as just two different charge states of the same entity, "nucleon", as was formally done by Heisenberg in 1932. The following analogy is quite suggestive in this connection.

Consider a physical system in ordinary space. The laws of physics do not depend on whether we are using a particular set of co-ordinate axes or the rotated ones. In other words, they are rotation invariant. This rotational symmetry leads to conservation of angular momentum.

In quantum mechanics, angular momentum can only take half odd integral values. Further, the projection of angular momentum J, on to a fixed axis, can only take the (2J+1) values. These are J, J-1, J-2,.......,-J. To use this analogy we postulate "charge-space", different from ordinary space and assume that the laws of nuclear forces are invariant under rotations here. This invariance would lead to conservation of angular momentum in this space, called "isospin", I. The neutron and proton are then to be regarded as two different projections of an I = ½ nucleon with projection I_3 on to a fixed axis being +½ for a proton and (−½) for a neutron. The importance of the isospin concept of nuclear forces was recognised by B. Cassen and E.J. Condon in 1936. N. Kemmer's analysis leads to I=1 for pions with I_3 having the value of pion electric charge in the units of proton electric charge.

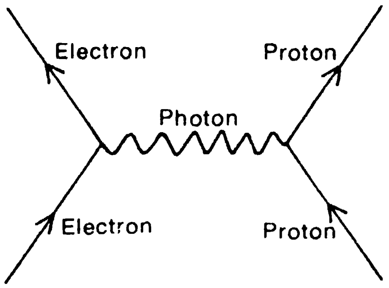


Fig 1 (a) Dirac's photon exchange mechanism for electromagnetic interactions between charged particles

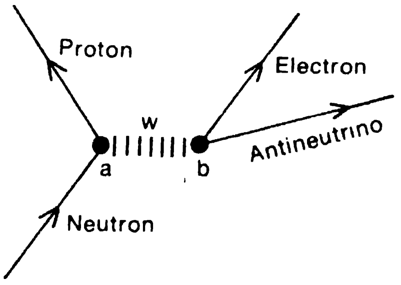


Fig 1 (b). Fermi's mechanism for weak interaction leading to beta decay of neutrons Fermi took the vertices a and b to be the same point Later, Yukawa suggested the exchange of charged intermediate W-boson quanta

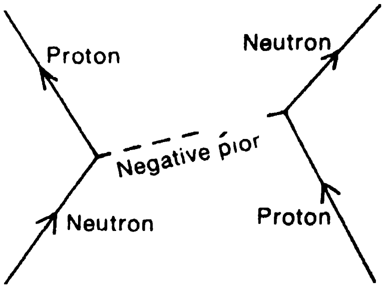


Fig 1 (c) Yukawa's pion — the lightest meson — exchange mechanism for strong nuclear force

It should, of course, be noted that if rotational invariance were an exact property of the laws of nature then the neutron and proton mass must have been exactly equal. The electromagnetic interaction, however, clearly depends on electric charge and to that extent provides a mechanism to induce a small neutron-proton mass difference. The same holds for the small mass difference between charged and neutral pions.

Apart from isospin, it is also necessary to assign to nucleons a linearly additive conserved quantum number, called baryon number, B, to account for the stability of matter. Current wisdom maintains that the protons are absolutely stable; we know that their lifetimes are greater than 10^{30} years. The neutrons can convert into protons as a result of either the Yukawa process or the Fermi process. We assign B=1 for nucleons (and B=−1 for antinucleons). The pions would have B = 0. The mass number of a nucleus is nothing but its baryon number.

Beginning with the observation of G.D. Rochester and C.C. Butler's of v-shaped tracks produced by cosmic rays in their cloud chamber photographs in 1947, a large number of new particles were discovered. These particles were copiously produced in the interactions of pions and nucleons, implying that they should be strongly interacting. That being the case, they should also decay, as these were all unstable (with lifetimes of about 10^{-23} sec). In contrast, their lifetimes were found to be about 10^{-9} sec. Such lifetimes are rather more characteristic of weak interactions. For this reason they were regarded as "strange particles".

The resolution of the strange particle enigma was found, in 1953, by M. Gell-Mann, and by N. Nakano and K. Nishijima. It involved the introduction of a new quantum number called "strangeness", S. The conventional particles such as nucleons and pions were assigned S=O, while the new strange particles were assigned the values S=+1 or -1. The strangeness, S, was regarded as a linearly additive quantum number and it was assumed to be an exact conservation law for strong and electromagnetic interactions. The production of these strange particles was taken to be due to strong interactions, thus explaining the large production cross-section for them. Since a pion-nucleon system has zero strangeness, we have to produce two strange particles of opposite strangeness together.

Since these new particles have strong interactions, the concept of isospin has to be extended to them, or else their presence in the virtual states would lead to the violation of isospin conservation.

If the strong and electromagnetic interactions only are present, these strange particles cannot decay into ordinary particles as this would involve a change of strangeness. Thus they can only decay by weak interactions, accounting for their long lifetimes. Indeed, to explain the existence of some decays and the absence of other possible ones, it must be assumed that weak interactions change strangeness by only one unit.

With the arrival of various high-energy accelerators and new experimental techniques, a very large number of new "hadrons" (strongly interacting particles) were discovered. Hadrons with baryon numbers equal to 1(-1) are called "baryons" (antibaryons), while those with baryon number zero referred to as "mesons". All known baryons have half-odd integral spin and obey Fermi-Dirac statistics (that is, no two baryons can occupy the same quantum state in a system). On the other hand, all known mesons have integral spin and obey Bose statistics (that is, any number of mesons can occupy the same quantum state in a system.)

The explosion in the number of hadrons encouraged the search for a pattern in their masses and quantum numbers and the successful phenomenological scheme (called "unitary spin", a generalisation of isospin) was found by M. Gell-Mann and Y. Ne'eman in 1961. To a crude approximation, the strong interactions among hadrons were found to conserve "unitary spin".

A remarkable fact of this ever-proliferating hadron spectroscopy was noticed by M. Gell-Mann and G. Zweig in 1964. They observed that all the known hadrons can be regarded as built out of three basic entities, named "quarks", having a spin ½ and baryon number equal to 1/3. The electric charge, in the units of proton charge, of the three quarks — "up quark", "down quark" and "strange quark" — is taken to be 2/3, –1/3, –1/3 respectively.

The up and down quarks carry zero strangeness while the strange quarks are assigned a strangeness equal to -1. The quantum numbers of the observed hadrons are consistent with baryons (being made of three quarks) and mesons (being a quark-antiquark pair). The observed pattern of the hadron masses requires the up and down quarks to have very nearly equal and small mass. This accounts for the observed isospin symmetry, where the strange quark is required to be a comparatively heavier mass.

The assignment of fractional baryon number and electric charge makes quarks very distinct and unusual entities. No free particles with such charges have been seen so far. However, in view of the overwhelming success of the quark idea, it is generally accepted that quarks do exist and one has to explore theoretical reasons for explaining their non-observance as free particles. This is the problem of "quark confinement".

Our present ideas on the interactions among the quarks are strongly prejudiced by the recent work on gauge theories of weak interactions and their unification with electromagnetic forces. Let us, therefore, turn to these developments which have been among the most exciting in the last decade.

Electroweak unification

In his paper on the meson theory of nuclear force, Yukawa also envisaged the possibility of the weak interaction being mediated by another quantum, now termed the weak vector boson. Clearly, this weak vector boson must be immensely heavy to account for the almost zero range of weak interaction. This weak boson must be electrically charged, since pairs involved in weak interactions (such as electron-antineutrino etc) are charged. We must have massive particles of positive charge W^+ and negative charge W^-. In contrast, the photons, which are the quanta of the electromagnetic field, are massless and electrically neutral. Not only that, electromagnetic interactions are much stronger in weak interactions. Further, they, unlike weak interactions, respect space-reversal invariance. It would thus seem that these two interactions are hardly the suitable candidates for unification.

The crucial element in this unification has been the hope of a gauge theory of interactions with the idea of spontaneous symmetry breaking. What makes this line of development possible is the spin-one nature of both $W^\pm$ and the photons.

Gauge theories

Hermann Weyl (1918) in attempting to unify gravitation with electromagnetism argued that in "a truly infinitesimal geometry" it should be possible to make changes in the gauge from point to point in space-time (that is, the theory should have "gauge invariance"). In this theory, the changes in scale corresponded to changes in electromagnetic potentials by the addition of a gradient of a gauge function. These changes, however, kept the electric and magnetic field strengths unchanged.

Physically too, we know that the electromagnetic phenomena do not change under such changes of electromagnetic potentials. For example, the force between two electric charges is independent of whether the system is in a laboratory at zero or finite constant electric potential. Later on, with the discovery of quantum mechanics, it was realised by H. Weyl that the deep property of gauge invariance of Maxwell's equations is more naturally connected to the description of electrically charged fields in quantum mechanics, rather than to gravitation. While the original concept of gauge invariance has disappeared, the name has persisted and it is used now to denote any invariance under transformations in which changes are dependent on the space-time point. It is amazing how Weyl's ideas, given in other contexts, have been successful when applied to weak interactions.

The fields of charged particles are described by complex number valued space-time dependent functions. Now, a complex number is described by its modulus and phase. As all observable physical quantities involve a charged particle field and its complex conjugate at the same space-time point together, we are allowed to change this phase by the same constant amount over the whole space-time without affecting any physics. It would be aesthetically more pleasing if the phase of a charged particle field could be arbitrarily fixed at all space-time points. In quantum electrodynamics of charged particles, it turns out that this is indeed possible.

The complete arbitrariness of the phase can be achieved by a corresponding change in the electromagnetic potentials. The theory, thus, has this rather remarkable "gauge invariance" property of being able to choose an arbitrary space-time dependent phase for charged particle fields. Not only that, our aesthetic requirement indeed predicts the existence of Maxwell fields, with zero mass and spin one quanta.

C.N. Yang and R.L. Mills, and also G. Shaw solved (1954) the difficult problem of how to write down a similar theory when the conserved quantum carried by the field are not like electric charges which are linearly additive, but are rather like "isospin" which is vectorially additive. The 'Yang-Mills gauge theories" predict, in general, the existence of a number of massless spin-one quanta. Since, apart from photons, no massless spin-one quantum has been seen, it would appear to be another case of a beautiful theory not squaring up with the "ugly" facts of nature.

It is here that the idea of "spon-aneous symmetry breaking" comes o our help. To illustrate this idea, let us take a simple example which s from classical physics. Consider a bowl which is symmetric under rota-ions about, say, its vertical axis. In general, it is shaped as in Fig. 2(a). f a small ball is allowed to roll in the bowl, its equilibrium position would be at the bottom of the bowl at C. Note that the point C does not change under rotations about the vertical axis. Here, we have a solution having he symmetry of the problem. This is he general case. Consider, now, another situation shown in Fig 2 (b), where the bowl has the same symmetry (it is still symmetrical under rotations about its vertical axis). Now, the point C′ at which the symmetry axis meets the bowl is a hump of the bowl. The equilibrium position of the ball rolling in the bowl would now be at *one of the points* on the circle along which the bowl has the trough. Clearly, the position of the ball is not on the symmetry axis and we have an asymmetrical solution. The symmetrical position in this case is unstable. This idea is rather powerful in that it allows us to deal with an "ugly" (unsymmetrical) situation by using a "beautiful" (symmetrical) equation.

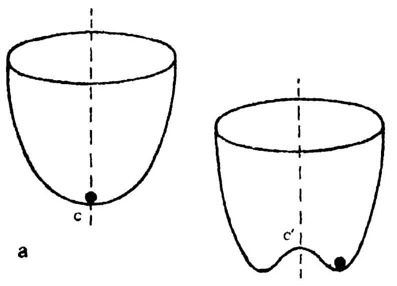


Fig 2: Equilibrium positions for a ball freely moving in a symmetrical bowl illustrates the idea of spontaneous symmetry breaking. In (a) the ball occupies the position on the symmetry, while in (b) it takes the broken symmetry position

We can, therefore, look for unsymmetrical solutions for the Yang-Mills field equations and hope that these solutions will correspond to massive spin-one quanta, unlike symmetrical solutions which correspond to massless spin-one quanta. Here one was, however, up against another difficulty. Such solutions in quantum field theory are accompanied by the existence of massless spin-zero bosonic quanta called 'Goldstone bosons" after their discoverer. In the case of a ferromagnet these Goldstone bosons refer to "magnon" excitations.

It was, however, realised by Peter Higgs in 1964 and also by R. Brout and F. Englert, that the difficulty of having massless Yang-Mills quanta and massless Goldstone bosons cancel each other. Note that the massless Yang-Mills quanta, like all spinning massless particles, have only two degrees of polarisation while massive spin-one quanta must have three. Goldstone bosons, together with massless Yang-Mills quanta, have a sufficient degree of freedom for a massive Yang-Mills quanta. This is known as the "Higgs mechanism".

The way is now open to consider gauge theories of interactions, such as the weak interaction, which are mediated by massive spin-one quanta. Further, since electromagnetism is also a gauge theory, one can hope for their unification.

Salam and Weinberg model

A successful application of these ideas to achieve a unification of weak and electromagnectic interaction for non-hadronic particles was achieved by S. Weinberg and A. Salam around 1967-68. In fact, beginning with J. Schwinger's suggestion of a possible unification of these two interactions in 1957, there had been various attempts at it by J.C. Ward, A. Salam, S. Glashow and S. Bludman, among others.

The model dealt with the electron, the muon and associated neutrinos, and is based on the assumption of symmetry leading to conservation of a "weak-isospin" and a "weak-hypercharge" quantum numbers the original equations of motion. All these particles, referred to as "leptons" (that is, fermionic non-hadrons), have spin ½. The electron and the muon have two polarisation states which are referred to as "left-handed" and "right-handed". The neutrinos, being described by Weyl's equation, have only one state of polarisation and are purely "left-handed". The electronic neutrino and the left-handed electron are regarded as "weak isospin" up and down states respectively of the same entity, while the right-handed electron is assigned zero "weak isospin". Similar quantum numbers are assigned to the muon and muon neutrinos.

The theory, given the assumed symmetry, requires three massive quanta W^+, W^- and Z^0 and one massless quantum which is identified with photons. The massive W^+ and W^- account for the observed charged-current weak interactions among leptons, while the Z^0 predicts a new type of weak interaction, called neutral current weak interaction, in which the weak interaction pairs involved would have zero net electric charges just as for electromagnetic currents. This new type of weak interaction, in which an incoming electronic (or muonic) neutrino, interacting with matter would not change into an electron (or muon) but would give rise to an outgoing electronic (or muonic) neutrino was totally unexpected at the time of its prediction.

Partly due to this reason, but probably more due to the belief that this theory would be plagued with uncontrollable infinite expressions due to the presence of massive spin-one particles in it, the idea was not taken seriously. In 1972 Gerard t'Hooft, then a young student, showed that the theory was "renormalisable". Thus, logically, the theory was as much consistent as the successful quantum electrodynamics. Hooft's demonstration caused enormous excitement and the Weinberg-Salam model began to be taken seriously.

Spurred by the theory, a search for particle interaction giving evidence for this new weak interaction (for "neutral current" events) was carried out and indeed they were discovered in 1973.

Charm

Can the Salam-Weinberg model be extended to cover the description of weak interactions of hadrons? The charged current or the traditional weak interactions of hadrons, includ-

Fermions are the constituents of matter. They have a half-integral spin and obey Fermi-Dirac statistics. All of them have anti-particles of the same mass but an opposite electric charge and magnetic moment. The neutrinos, which are chargeless, spin in a left-handed sense relative to their direction of motion, while the anti-neutrinos, which are also chargeless, spin in a right-handed sense. Since the quarks are never seen alone their individual masses cannot be measured directly. But they can be inferred from the mass of hadrons of which they are integral parts. (The masses given in the table are effective "constituent" masses of the quarks obtained by "neglect of binding effects" among them.)

Note that the basic pattern provided by the up and down quarks is repeated by the other pairs of quarks. The same happens to leptons.

—Colour—

uarks	Electric charge	Mass Effective
Up	2/3	300 MeV
Down	−1/3	300 MeV
armed	2/3	1500 MeV
trange	−1/3	500 MeV
Top	2/3	Not seen yet
ottom	−1/3	5000 MeV

—Colourless—

Leptons	Electric charge	Mass
Electron	−1	0.511 MeV
Electron neutrino	0	0 (< 60eV)
Muon	−1	106 MeV
Muon neutrino	0	0 (<65 MeV)
Tau	−1	1900 MeV
Tau neutrino	0	Not seen yet

Bosons given below provide binding forces to hold particles together, that is, they are quanta of interaction. They have integral spin and obey Bose statistics

Photons are quanta of electromagnetic field. They are of one kind, have a spin equal to one and are massless. They do not change the particles they interact with.

Gluons are quanta of strong interaction. They are of eight kinds, have spin equal to one and are massless. They act as a glue holding together quarks and in the process change the colour of the quarks.

[illegible]

[illegible]

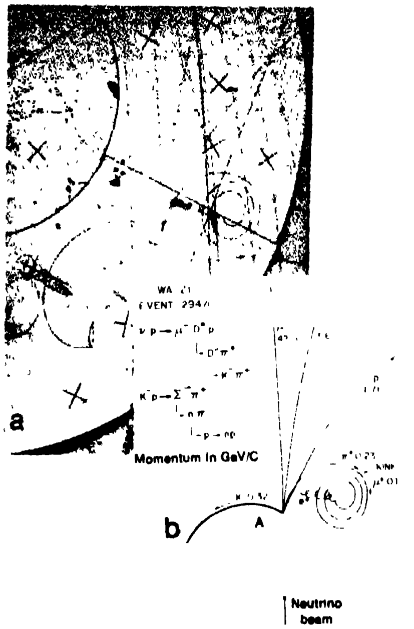


Fig 3 (a): A clear example of the production of a charmed particle as seen in neutrino interactions at the Big European Bubble Chamber. Fig 3 (b) gives a diagrammatic interpretation. Note the sequence of events: A neutrino from an incoming neutrino beam hits a proton in the bubble chamber liquid at A and produces a negatively charged muon (μ^-), a proton (p) and an unstable charmed D^* meson which leaves no track since its decay is very fast. The D^* meson in turn decays into a neutral charmed D meson (D^0) and a positively charged pion (π^+)

ing those of strange particles, are described by an extension of the V-A theory, proposed by N. Cabibbo in 1963. In view of the compositeness of the hadrons, it is found more accurate to replace the neutron-antiproton pair by another pair involving quarks, namely the "d_c- $\bar{u}$ " pair. Here $\bar{u}$ is the anti-up quark and d_c is the "Cabibbo rotated down quark". The d_c is not a pure down quark but is rather a down quark with a small admixture of strange quarks. The principle of linear superposition in quantum mechanics allows for such admixtures.

A straightforward extension of the Salam-Weinberg model, with the addition of the Cabibbo pair (by adding another contribution in which electron and neutrino are replaced by d_c and u, respectively), does have some undesirable features. It predicts sizeable new neutral current weak interactions involving a change of strangeness. Such an interaction, being rather easy to detect, should have been observed without much effort. For example, the long-lived kaon, which carries strangeness, should decay into a non-strange muon-antimuon pair. Indeed, it was the absence of this decay mode of the kaon which was responsible for the general belief that neutral current weak interaction do not exist.

The appropriate extension of the model uses a mechanism, discovered

Sheldon Glashow, Steven Weinberg and Abdus Salam. Although the unification achieved by them is slightly incomplete, their contributions seem to have taken particle physicists to the threshold of their ultimate goal of finding a single force to account for all natural phenomena

by S.L. Glashow, J. Iliopoulos and L. Mainai (GIM) in 1970. This mechanism introduces a new quark, named the charmed quark, having the same electric charge as the up quark u, and carrying a new quantum number "charm". One elaborates the straightforward extension, mentioned above, by adding a contribution in which $\bar{u}$ and d_c are, respectively, replaced by C and S_c. Here S_c is a strange quark with a small admixture of d quark in such proportions that d_c and S_c quark combinations have zero overlap. The model now has no strangeness-changing neutral current weak interactions, and, in this form, is in accord with experimental data available.

The new charmed quark had been introduced earlier by S.L. Glashow and J.P. Bjorken in an attempt to consider symmetric patterns higher than those provided by the unitary symmetry scheme. In order that the GIM mechanism be acceptable, it was necessary to have some evidence of this "charmed quark". The discovery of the particle psi with a mass of 3.1 GeV, which had an unusually long lifetime for its mass (by S. Ting of the Massachusetts Institute of Technology, USA, and B. Richter of Stanford Linear Accelerator Center (SLAC) and their groups in 1974) was therefore very welcome for this approach. It was gradually agreed that the most reasonable explanation of unusual properties of the psi particle, and of a number of related subsequent discoveries, was that it was composed of a charmed-anticharmed quark. Ting and Richter were awarded a Nobel prize in 1976 for this discovery.

Electro-weak Interactions

We have thus seen how various experimental phenomena acquire a definite order within the Salam-Weinberg scheme augmented by the GIM mechanism. Since this theory is based on two distinct symmetries ("weak isospin" and "weak hypercharge") it has two coupling constants which fix the strength of the relevant interactions. One of these is essentially the fine structure constant as befits a theory which unifies it with electromagnetism. The other parameter is taken in the form of an angle, called Weinberg angle, and is not fixed from pure theory in the model. If we take the value of this angle from the experimental data, then the masses of W^+(and W^-) and Z^0 boson quanta, whose exchange gives rise to charged current and neutral current weak interactions, respectively, is fixed to be about 75 and 85 times the proton mass respectively. The difficulty of exchanging such massive quanta between two fermions explains the short range and weakness in low energy phenomena of weak interactions. The possible discovery of these vector bosons by the next generation of accelerators would be a great event.

The unification achieved here between weak and electromagnetic interaction into one basic "electro-weak" interaction is not as complete as was the unification between electricity and magnetism achieved in the last century by Maxwell and Faraday. We still have a free parameter (Weinberg's angle in the theory). Nor have we observed any phenomenon analogous to those observed by Oersted, Ampere, Faraday and others, for example, those in which electromagnetic interactions would induce a change in a typical weak interaction quantity such as beta decay rate. Last year's Nobel prize award to Glashow, Salam and Weinberg recognises the present unification — a result of the tremendous theoretical and experimental work of the last decade — as an important landmark in our understanding of basic interactions.

Grand Unification

Armed by the success of the gauge theory approach for electro-weak interactions, it is natural to look for a gauge theory of strong interactions as well. One may even hope for the "Grand Unification" (of electro-weak interactions with strong ones). As pointed out earlier, the basic strong interactions are the strong interactions among the quarks, since all known hadrons are a composite of quarks. The interactions among hadrons are "secondary" and should be derivable from the "primary" quark interactions. The leading contender for such a theory is quantum chromodynamics (chrome = colour).

The quarks are regarded as spin ½ particles. All known particles with spin ½ obey Fermi-Dirac statistics. Thus, no two of them can occupy the same state. However, in a doubly-charged nucleon isobar, of mass about 1240 MeV, one has three up quarks occupying the same state, apparently violating the general rule. To bring the quarks in line with all the other known particles, it was suggested by O. Greenberg (1964) that quarks be assigned a new quantum number, "colour". Three possible "colours" were named "red", "white" and "blue" after the colours of the American flag. The quarks now can be taken to be fermions. All the conventional hadrons have been found to be "colourless", they do not carry colour quantum number. Further evidence for this new quantum number comes from the observed decay lifetime of a neutral pion and the cross-section for the electron-positron annihilation of hadrons.

The usual quantum numbers which distinguish up, down, strange and charmed quarks such as isospin, strangeness and charm are now referred to as "flavours", in contrast to colour. A quark has both flavour and colour. The electro-weak interactions are essentially a gauge theory based on flavour quantum numbers and are sometimes called "quantum flavour dynamics". It is, therefore, tempting to postulate a "quantum chromodynamics" based on the colour quantum number for strong interactions among quarks. This gauge theory would have sight coloured quanta, termed "gluons", as they glue quarks together. These eight gluons would be massless since, unlike flavour symmetries, the symmetry giving rise to colour quantum number is exact. If it were not exact, the observed hadrons would not have been purely colourless objects. Clearly, these coloured gluons, just like coloured quarks, must also be unable to exist in a free state and thus must be confined within hadrons. Or else, we should have seen these massless quanta as observed physical particles.

Is there any evidence for gluons and this gauge theory? We first note a very attractive feature of this theory, called "asymptotic freedom", noted by H. Politzer and by D. Gross and F. Wilczek in 1973. In quantum chromodynamics, the interactions among quarks become weaker as shorter distances are encountered. Now, this is a feature which was encountered in deep inelastic electron and neutrino scattering on nucleons. The nucleon was found to behave like a system of three "valence" quarks and a sea of quark-antiquark pairs with vacuum quantum numbers, moving more or less freely inside the nucleon, in these experiments. The data obtained gave a lot of information on the momentum distribution of valence and sea quarks inside the nucleon. A surprising feature of these measurements was that the momentum fraction carried by the quarks and antiquarks was roughly one-half of what it should have been if there were no other constituents inside the nucleon. Since these experiments only probe those constituents of the nucleon, which have electro-weak interactions, there must be others which are neutral to these interactions. It is natural to identify these electro-weak neutral constituents with gluons. Further evidence for this theory has come from studies of jet phenomena encountered in electron-positron annihilation studies (see Round-up of Research, November 1979).

Proton decay

There have been a number of attempts to unify quantum flavour dynamics with quantum chromodynamics. One hopes to learn more about both electro-weak and strong interactions that way. For example, one can fix the value of the Weinberg angle from such considerations.

The hallmark of such theories is the possibility of proton decay. To avoid this possibility, one has to consider rather contrived models. This unification involves considering leptons and quarks as different states of the same basic entity. It is natural that quarks must be able to transform into leptons. This, in turn, means that protons, which are composed of quarks, should also decay into leptons.

A curiosity is that nature seems to be making "Xerox copies" of the basic pattern shown by the up and down quarks, together with the electronic neutrino and the electron. These "Xerox copies" seem to differ just in their mass and the copy number, that is, electronic, muonic or tauonic. The copy number is also referred to as "generation". The old question, "who ordered the muon" becomes more acute and may, therefore, get solved in the future.

This increase in the number of quarks has, however, a welcome feature. We now have the minimum number of quarks to accommodate the CP violation seen in some kaonic decays, within the present gauge framework, following a suggestion of M. Kobayashi and K. Maskawa (1973).

The present experimental limits on proton lifetimes are already quite large. It is known to have a lifetime greater than 10^{30} years. An amusing, but considerably weaker, limit of 10^{16} years on proton lifetime follows simply from the fact that the human frame does not decay appreciably due to radioactive causes over its lifespan. The gauge quanta which are responsible for proton decay have to be extremely massive, with a mass of the order of 10^{15} proton masses, and have been nicknamed "intermediate vector baseballs". In most models, the estimated lifetime of the proton is around $10^{32\pm2}$ years. Thus, determining this lifetime is going to be a very crucial experiment as it would, if the proton is found to decay, tell us whether the general picture of unification of strong and electro-weak interactions that way For example, iments are planned both in Europe and USA at present, and an answer can be expected in a few years.

If the above picture is correct, it has tremendous possibilities for astrophysics in that it may account for the present baryon excess in the universe.

Future outlook

Our present understanding of the structure of matter—ignoring large-scale structures where gravitation is all important—is based on the matter being composed of spin $1/2$ particles, leptons and quarks These particles interact via the exchange of spin-one quanta of the gauge fields, gluons, photons and intermediate bosons such as W^+, W^- and Z^0. There are four quarks, namely up, down, strange and charmed, each with the three colours, and these quarks, respectively, are analogous to the four leptons, electronic neutrino, electron, muonic neutrino and muon. Indeed this quark-lepton symmetry was one of the reasons for advancing the existence of the charmed quark before it was discovered.

Recently (1975), a new, electrically charged lepton, tau, with a mass of 1.9 GeV, was discovered at SLAC by M. Perl and his group. Almost certainly, the tau is accompanied by a massless tauonic neutrino. One therefore expects two more quarks and these have been named "top" (or "truth") and "bottom" (or "beauty") quarks and should have the electric charge $+2/3$ (like the up and charmed quarks and $-1/3$ (like the down and the strange quarks) respectively. There is general agreement now that evidence for the bottom quark, with a mass of about 5 GeV, is pretty strong.

But, the difficult question is, are quarks really confined? And if so, why? It is believed by some that pathologies associated with zero mass gluons are responsible for this. Another intriguing problem is why some symmetries are spontaneously broken and some are not. A suggestion is that this is due to the universe being very cold now. This is in analogy to crystals exhibiting broken rotational-translation symmetry of the laws of atomic physics. At higher temperatures crystals melt and symmetry is gradually restored. Maybe it is so.

A major question is about new physics beyond energies of a few hundred proton masses. Orthodox believers of the Grand Unification would say that nothing basically new would happen until we come close to energies of the order of "intermediate vector baseball" masses (that is, 10^{15} GeV). At these energies both electro-weak and strong interactions would be equally strong. There is thus a huge desert between these two energies. While there are some attempts to make this desert bloom, the whole thing is rather disconcerting. Probably great surprises are in store.

Coming to the oldest known force, gravitation, we still seem to lack a convincing idea as to how it is to be unified with other forces. In 1915, for the first time since Newton, the theory of gravitation was given a completely different conceptual look by Einstein in his general theory of relativity. This is a well-discussed subject. Einstein's theory, being based on tensors, requires an exchange of massless spin-two quanta. Since gauge theories require spin-one quanta, gravitation looks a little different. Einstein's dream of unifying gravitation and electromagnetism still remains unfulfilled.

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The scene of the crime

Pritam Phatnani

Continuing to listen to the dead men, we come to the third of the W's which tells us the importance of knowing *where* the victim was killed

AT ABOUT 9 a m on 15 August 1975, a gunny bag containing the dismembered parts minus the head of a human body was found in the break-van of a Bombay local train. The "case of the headless body", as it soon came to be known, confronted the police with many baffling questions: Where had the body come from? Who was the dead man? When did he die? And, having been found in a train that ran between a far-off suburb and the metropolis, *where* was he killed?

Finding the body of a murdered man at one place does not necessarily mean that he was murdered there. Calculating criminals often have the habit of dumping a body far away from the scene of crime in an attempt to mislead the police. Very often, this happens when victims are new born babies. Indeed, the police can often be misled to suspect a wrong person, or may not find sufficient evidence to suspect anybody at all, till they come to know where exactly the murder took place.

The dismembered limbs and torso found in a railway compartment created many landmarks in crime detection

In all such cases, it is the forensic pathologist who has to play Sherlock Homes. But he does it in close cooperation with the police. A thorough search of the area where a body has been found does indeed offer clues on the original scene of a crime, which in turn can point to evidence regarding the criminal himself.

Since the body is often found in strange places, unfamiliar even to the victim himself, the first difficulty the police has to overcome is of establishing the identity of the victim. The physical facts associated with the body play an important role in establishing the correlation between the two places concerning the crime. Here, medical evidence alone does not play a decisive role. It supports the physical evidence and sets the investigation in a proper direction.

In the above case, the neatly packed body carried no evidence that the crime had been committed in the train, so the police looked elsewhere. Obviously, the procedure of killing, dismembering, and packing off would have taken considerable time and an act like that in a crowded city like Bombay would not have gone unnoticed had all these been done in the train itself.

The investigators had initially to work on assumptions. The first assumption was that the dead man belonged to a western suburb of Bombay, since the train ran on the Western Railway that touches the western suburbs of the city.

Strangled baby boy done away just after birth. When infants are the victims it becomes easy to remove the body to a far-off place

Later, this assumption proved right, but who could be the victim? Without the head, identification was difficult. Luckily, the forensic pathologist decided to preserve the victim's finger tips in a formalin solution before the other pieces of the body — by now in a decomposed condition — were discarded. This proved to be a clinching factor.

The postmortem examination revealed that the deceased was in his forties, possibly a Hindu, with average height and weight. He had died about 48 to 72 hours prior to the postmortem examination performed in the afternoon of 16 August. He had eaten his last meal three to four hours prior to his death, and it was a non-vegetarian meal. He had also suffered from diseases of the blood vessels for which he might have taken medical advice.

Deductions alone

The forensic doctor cannot always employ chemical or laboratory means to find out where a person was killed and, unlike in the case of determining the time factor (see SCIENCE TODAY, February 1979), the investigators often have to proceed by deductions alone. And that was precisely what had now to be done in the case of the headless body. For, in the meanwhile, it appeared that the killer had started his second phase of operations to mislead the police.

Letters from a powerful labour union leader of Goregaon, a western suburb of Bombay, started arriving at various places, explaining his sudden disappearance. Was the victim, then, the missing labour leader? And was the killer trying to establish an alibi for himself by trying to make everyone believe that the man he had done to death had not died at all? The persons to whom the letters were addressed, all acquaintances of the missing union leader, became suspicious. For, neither the handwriting nor the style of the letters was anything like that of the labour leader. That got the police studying in detail all about the last activities of the missing man.

Before his sudden disappearance, the labour leader had been busy settling the bonus issue for the workers at his factory. Interestingly, one of "his" letters, addressed to the factory owners, authorised an assistant of his to collect the bonus money on behalf of the workers. A picture was now emerging — maybe the headless body belonged to the missing union leader. And, maybe, the assistant had a hand in the crime.

The police soon discovered that the missing union leader had once been arrested in March 1952, twenty-three years earlier, and that his fingerprints were on record. Also, he had, for a time, been enrolled in the navy. The navy too had a record of his fingerprints. That's where the shrivelled up finger tips preserved in formalin earlier became useful.

The finger tips had to be rehydrated using glycerine. The use of glycerine to rehydrate shrivelled parts of the body is an age-old method. But there is, today, a more sophisticated method employed by Prof. Keith Mant of Guy's Hospital, London. He uses a photographic solution made by Eastman Kodak (Eastman Photo Flo 200) to rehydrate tissues rapidly. Unfortunately, that solution was not readily available, but the glycerine did the job with equal success.

Next, the rehydrated superficial layer of the skin from the finger tips were peeled off, sandwiched between two glass slides and, illuminated from below, photographs of it were taken. The prints thus obtained were perfect for matching. A comparison with the old police and naval records ended the suspense. They were found to be absolutely identical!

Calculated murder

Once the identity was established, the rest of the investigation became easy. The assistant of the deceased became the prime suspect. A search of the premises of the deceased revealed that the murder had been committed there, with a bizarre sequence of events. The killing took place on the night of 13/14 August 1975, possibly past midnight, after the victim had consumed food and a lot of alcohol around 10 p m. He was beheaded with a meat chopper and dismembered in the bathroom where all the blood was allowed to drain off. The dismembered parts were later packed in the gunny bag and taken to the railway station around 5 p m.

Clearly, it was a cold-blooded and calculated murder. The killer had purchased on the 13th morning the mutton chopper and the bag. These items were subsequently identified by the respective shopkeepers who had sold them to the murdered labour leader's assistant.

Placed together, the remains of a man picked up one by one from a pond provided the size of the victim, which did not help much in the identification. Other items (top of page), g with these, provided the clue

Charred portion of the *nevar* used for strangulation (top) and bits of the leather belt (bottom) worn by the victim helped in the identification and in ascertaining the cause of death

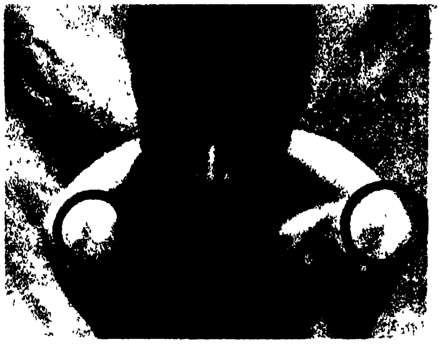
Humans alone are not always responsible for removing a body from the scene of death. Flowing water or animals at times could do the same. One interesting case on record is that of a drunken young man who had slipped and plunged headlong into the cemented floor of a sewage canal. Postmortem examination showed that death had been instantaneous, but the body floated along till it hit a tree-trunk and remained there till it was spotted. The postmortem examination, a careful surveillance of the canal area, a knowledge of the course of water flow (which in this case was dependent on the tides in the sea, since the sewage canal led to the sea), and a study of the activities of the deceased helped reconstruct the course of events and establish that it was an accident and not murder.

Physical evidence

On rare occasions, the physical evidence present on an accused person may offer a valuable clue and support the evidence that a death had occurred away from the site where the body was recovered. One such case occurred in 1973. The body of a young woman in her twenties was recovered from a well in Andheri, another western suburb of Bombay. As the body was found neatly tied up in tarpaulin with a coir rope, it was clear that the murder, which was by strangulation, had not taken place in the well.

Identification and further investigations revealed that she had a lover, a young man, whom her family did not approve of. As such, she was to be married off to another man. Her lover (who was also the person with whom she was last seen out) was brought to the police station for investigation. He had small abrasions on the top and back of his shoulders, the patterns of which resembled the rope marks on the victim's body. The man admitted having committed the crime. He said, "If she couldn't be mine, she couldn't belong to anyone else either."

The rope marks were the only positive link that provided direct evidence that the man must have killed his girl friend. The abrasions proved that the body had been moved away from the scene of the crime to destroy evidence. For, the manner of the marks and their position on the man's body seemed to indicate clearly that the weight of the body, tied with the rope in the tarpaulin, had pressed continuously against him while he carried it on his back a whole kilometre before throwing it down the well.



Circles indicate rope marks on the man's shoulder

In yet another case, parts of a human body — first the torso and the right thigh, then the two legs, and lastly the hands and parts of the broken skull bones — were recovered over a period of three days from a pond at one end of the runway of Bombay's Santa Cruz airport. The pieces were tied up in different gunny bags, along with stones, so that they would not float. After the pieces were put together, it became obvious that the dead person was a man about 185 cm tall. No superimposition or reconstruction of the face was possible as the skull bones had been destroyed. Chemical analysis did not detect any poison and the death was presumably the result of violence.

Visit to the spot

After identifying the body, and getting information from the prime suspect, the owner of a liquor den, a visit to the scene of the crime helped the police recover enough evidence to suspect three more persons. The police found partially burnt pieces of the clothing that smelt of kerosene, pieces of the leather belt worn by the deceased which, though burnt, could still be identified, and, most important of all, a noose made of partially burnt *nevar* (the strap used for making cheap cots) with its knot still intact.

With all this it was proved beyond doubt that after killing the man with the *nevar*, they poured hydrochloric acid over the face, doused the body in kerosene and set it on fire before disposing it in the pond. Having learnt that much, three of the four suspects were incriminated as they had their hands painted with *mehndi* (henna). They did so to hide the burns they had received while handling the acid. Had the police not ascertained the scene of the crime, in this case too, it would have been impossible to book the guilty.

What to look for

The Glaister principle of physical exchange between the scene of disposal of a dead body and the persons involved in the crime can point to the actual scene of the crime. Doctors, forensic scientists, ballistic experts, photographers, and the police have to work hand in hand to correlate the evidences gained.

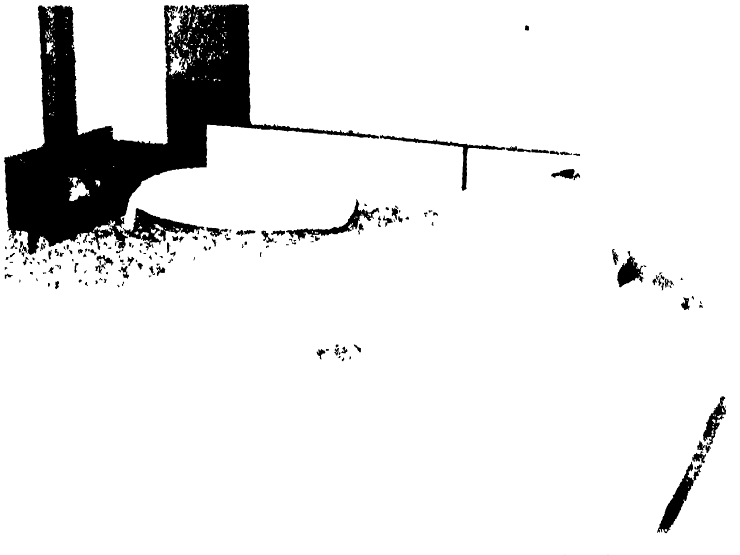
Much depends on how well the spot where the body was found is observed and examined, and how carefully the body is handled. In case of firearm injuries, a ballistic expert has to be present. Likewise, where motor vehicles are involved, an automobile expert could help.

What has to be noted most carefully would be (a) the disturbed (or undisturbed) positions of the objects, their relocation, or any missing objects. A murdered person lying on a bed (see photograph) with the sheets undisturbed could indicate that the murder did not take place there; (b) the distribution, direction and character of the blood stains (see Science Today, January 1973); and (c) the presence of objects at the scene. Even fragments of glass, wood, metal, paint, locks of hair, pollen grains, shirt buttons (remember the movie *Rider on the Rain*), weapons, and foreign soil that does not fit in with the surroundings could be pointers to the place from where the body arrived. Taking photographs of the scene is a most essential part of the investigation (see Science Today, September 1974).

The presence of foreign bodies on the victim, the nature of any wounds, and an examination of the blood and seminal stains (where sexual assault was involved) on the body can provide the clue. In cases of drowning, the discovery of diatoms, vegetation, or micro-organisms found in the water that may have entered the blood circulation could help.

The clothing worn by the suspect, the presence of stains on them, foreign pubic hair in the vicinity of the suspect's genitalia, or the victim's skin tissue on the suspect's nail clippings may also offer a clue.

P.P.



Victim on undisturbed bed, indicating that murder took place elsewhere

Dr. Phatnani who now heads the medical education wing of a well-known pharmaceutical firm is an experienced forensic scientist

The law of first digits

With the rising popularity of pocket calculators, the use of logarithm tables is declining. Already our use of logarithms is largely restricted to four-figure tables, which fit in two printed pages. Half a century ago it was common for scientists and engineers to use logarithm books that ran to several pages, because accurate calculations had to be done using many-figure logarithms. It was found that in the logarithm books in libraries the *first few pages were consistently dirtier than the rest,* indicating that the users had more occasion to deal with numbers having smaller first digits, such as 1 and 2, than large digits, such as 8 or 9. This is truly remarkable, since one would expect that the numbers used by different scientists and engineers would be completely random and hence all the digits from 1 to 9 would occur equally frequently as initial digits.

Research conducted by the American physicist, Frank Benford, in 1938, established beyond doubt that the initial digits did not occur equally frequently, but their frequency of occurrence was governed by a precise and elegant mathematical rule.

Benford gathered a lot of numbers that users of logarithm tables were likely to deal with. These included atomic weights, molecular weights, surface areas of rivers and other such numbers from scientific and statistical tables. He also listed the street addresses of the first 342 persons named in the 1934 edition of *American Men of Science*. He then counted the number of times a given digit occurred as the first significant digit. He expressed this frequency as a fraction of the total number of entries, and got the following:

Initial digit n·	1	2	3	4	5
Frequency of n.	306	.185	124	094	080
Initial digit n·	6	7	8	9	
Frequency of n·	064	051	.049	.047	

What is surprising is that the fractions in the second row correspond very closely to the values of the function $\log_{10}(1+1/n)$:

n:	1	2	3	4	5
Log₁₀ (1 +1/n):	.301	.176	.125	.097	.079
n:	6	7		9	
Log₁₀ (1 +1/n):	.067	.058	.051	046	

The correspondence is so close that a coincidence can be ruled out. In fact, the evidence favours a law governing the occurrence of initial digits, a law which states that if we pick up a number at random from the scientific tables mentioned above, the probability that its initial significant digit is n is given by $\log_{10}(1+1/n)$. The above rule has come to be known as *Benford's law.*

An interesting fact is that a geometric sequence obeys Benford's law, provided that the ratio between two consecutive numbers is not a rational power of 10, in other words, is not of the form $10^{p/q}$ where p is an integer and q any non-zero integer. A simple geometric sequence is $2^0, 2^1, 2^2, 2^3$ ... where the ratio 2 is not a rational power of 10. If the initial digits of the numbers $2^0, 2^1, 2^2$, ... up to 2^{100} are tabulated we would get the following table:

Initial digit n·	1	2	3	4	5	6	7	8	9
Frequency of n:	30	17	13	10	7	7	6	6	5

Considering that only a limited number of terms were considered, the agreement with Benford's distribution is close enough to conclude that the powers of 2 do obey Benford's law. However, if we choose a geometrical progression having a ratio equal to a rational power of 10, such as 3, 30, 300, 3000, . . . (ratio 10) or 1, 3.162, 10, 31.62, 100 ... (ratio $10^{1/2}$= 3.162...) it is easy to see that Benford's law is not obeyed.

Thus an infinite number of geometric sequences can be found that obey Benford's law. Are there any other sequences that obey this law? Consider the following sequence of numbers: 1, 1, 2, 3, 5, 8, 13, 21, .. where each number is obtained by adding the two preceding ones. The reader will probably recognise this as the famous Fibonacci sequence. If F_n stands for the n^{th} term of the sequence then we have the following relation.

$F_n = F_{n-1} + F_{n-2}$

Compare the following distribution of first digits of the first 100 Fibonacci numbers with percentages according to Benford's law.

n.	1	2	3	4	5
Fibonacci sequence:	30	18	13	9	8
100 Log₁₀ (1+ 1/n)·	30.1	17.6	12.5	9.7	7 9
n:	6	7	8	9	
Fibonacci sequence:	6	5	7	4	
100 Log₁₀ (1+ 1/n)·	6.7	5.8	5.1	4 6	

Considering that only 100 terms were considered, the adherence to Benford's distribution is very close indeed. This is because the Fibonacci sequence is very nearly a geometric sequence. In this sequence the ratios between the successive terms are as follows: 1, 2, 1.5, 1.667, 1.6, 1.625, 1.615, 1.618, 1.618 ... It can be proved that as the order of the terms increases, the ratio tends to a limit equal to

$$1+\sqrt{5} \quad = 1.618..$$

The Fibonacci sequence is an additive sequence whose terms are obtained by adding the preceding two terms. In general, an additive sequence is obtained by adding the previous n terms, where n may have any finite value. Any additive sequence will tend to a geometric sequence. It can be proved that for the general case the limiting ratio, R, is related to the number n of the preceding terms that are added by the following equation:

$$n = \frac{\operatorname{Log}(2-R)^{-1}}{\operatorname{Log} R}$$

It should be evident from the above equation that for any possible value of n, R could not be a rational power of 10, and hence any additive sequence will obey Benford's law, provided a sufficiently large number of terms is considered.

It might be worthwhile to emphasise that nobody has yet come up with what might be termed a final theory to explain the occurrence of Benford's law among the apparently random numbers found in the reference books used by Benford. Though the literature on this problem has become very vast and technical, there is no satisfactory explanation of Benford's law in terms of physical principles or a purely mathematical theory. It remains one of the most peculiar and tantalising problems in mathematics.

However, taking a more mundane point of view, knowledge of the law could perhaps be put to some use. For speedy accurate calculations we now tend to use electronic calculators rather than the logarithm table. Now, if the numbers we use obey Benford's law, we could build calculators in such a way that the buttons and the circuits for the smaller digits are a little stronger than those for the larger digits. Typewriters could also be designed in a similar manner.

BASIL DAVIS

Mr Davis is lecturer in physics at St Edmund's College, Shillong, and is currently doing research in theoretical nuclear physics

Recommends reading · **1.** Raimi, Ralph, 1976 The First Digit Problem, *American Mathematical Monthly,* **83** (521-538). **2.** Davis, B., 1976 Some Remarks on First Digits, *Fibonacci Quarterly,* **14** (13-14)

If...

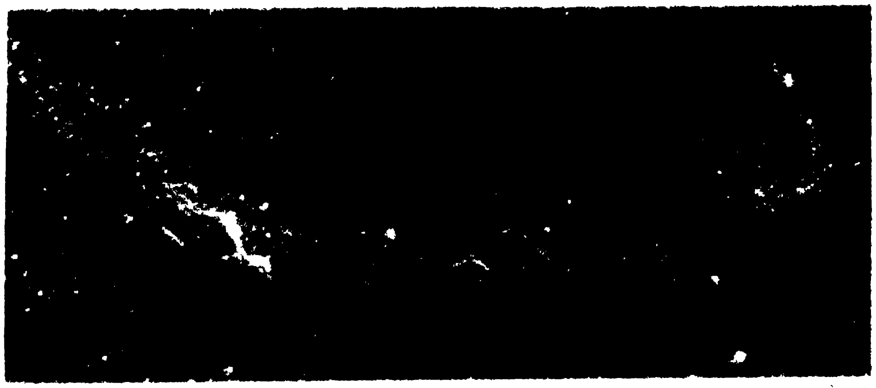
... a supernova were to occur near the solar system!

It is generally believed that every year, on an average, one star out of the hundred billion that make up our galaxy ends its life after exhausting its thermonuclear fuel. Most of the stars die tamely, but a few of them, with masses some ten times that of the sun, terminate their lives by undergoing a cataclysmic explosion resulting in a supernova. It is a spectacular event, but it is not frequent. Only three to four supernovae per century are expected to occur somewhere in the vast expanse of this galaxy. Spectaculars apart, a supernova explosion may also lead to the birth of new stars. There is in fact increasing evidence to suggest that our sun, with its planets, was formed when a massive star exploded in the vicinity of the primitive solar nebula. It was this explosion which was probably responsible for triggering the collapse of the gas cloud which produced a system of stars, including our sun.

Before the supernova explosion the massive star, in the course of its thermonuclear evolution, cooks a number of elements like carbon, nitrogen, oxygen and iron in its interior. This processed material thrown out during the explosion will be injected into the nebula.

It is therefore not altogether idle to enquire what would be the influence of a supernova outburst on the solar system, if one were to go off within, say, 100 light years from us (a light year being the distance travelled by light in one year at the speed of approximately 3,00,000 kilometres per second). This does not seem at all unlikely, if one takes seriously the claim of theoretical astrophysicists that within a distance of 100 light years there is a supernova occurring every few hundred million years. Such a supernova would appear to shine as a bright star, visible even in daylight for several weeks like the one the Chinese observed in July 1054.

Our ancestors, several tens of thousand years ago, while chasing wild game in the jungles, might have witnessed such a spectacular sight in the form of a flash of light, and were probably overwhelmed by the appearance of the unusually bright object in the sky. The outer layers of the massive star were probably thrown out violently and the debris raced through space travelling at an incredible speed of several hundred kilometres per second. Although the light flash must have reached the spectators within about 100 years, debris consisting of processed matter would eventually encounter the sun in a few tens of thousand years, and the solar system would be showered with this material.



A supernova shell — the Bridal veil nebula

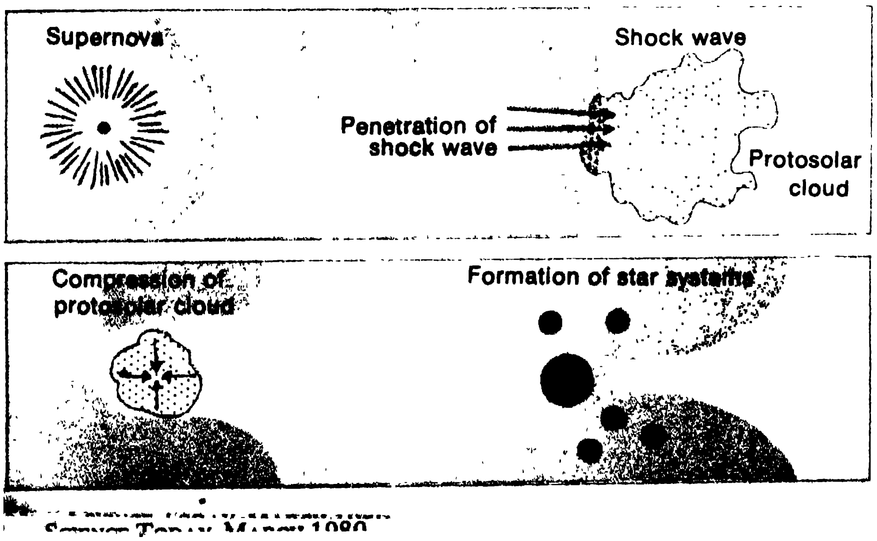
Should such a far off supernova shell arrive in our neighbourhood now it will produce disastrous effects in the solar system. Imagine the consequences on the earth's atmosphere, in particular on the ozone layer which shields the earth's surface from the intense ultraviolet radiation coming from the sun. The whole chemistry of the earth's atmosphere could be affected by such an event. The energetic particles from the supernova will get into the stratosphere and react with **molecular nitrogen (N_2) to produce free atoms of nitrogen. In the process, this will set up a chain-reaction involving oxygen which leads to the creation of nitric oxide (NO). It is the nitric oxide which reacts with ozone and produces oxygen molecules. It maintains the level of NO but, unfortunately, it also depletes the concentration of ozone.**

The removal of the ozone layer will also expose the earth's surface to a flood of ultraviolet radiation in spite of the resilience of the earth's ozone layer. The ultimate biological consequence for most terrestrial life in the presence of such a substantial dosage of ultraviolet radiation would be devastating. The incidence of skin cancer and the effect on the growth of tissues will directly affect the living beings. The animal kingdom, including the human beings, will be wiped out gradually from the face of the earth. It is not implausible that a few times in the history of life on earth more than 90 per cent of our ozone umbrella may have disappeared for several tens of years. Such biological cataclysm, and the consequent deluge, might indeed have brought about the disappearance of animal life in the past, and may continue to threaten occasionally the higher forms of life.

Then there will be the direct effect of the increased ultraviolet radiation on the temperature of the earth's atmosphere; this will induce global climatic changes leading to a change in the surface temperature up to one degree centigrade, with what eventual effects it is difficult to imagine.

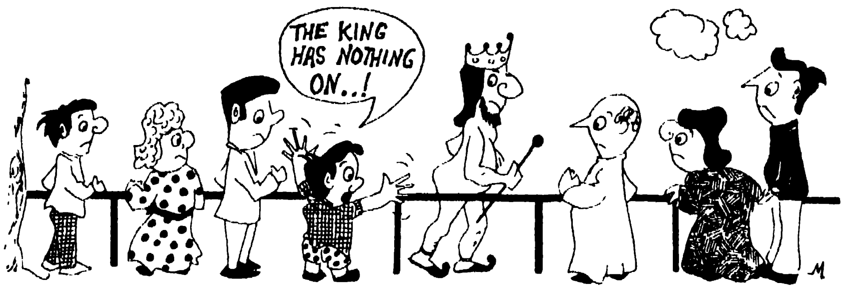
The plants will not be spared either. The plant life will wither away as the photosynthesis rate gets substantially altered. The dwindling human population which places such a heavy reliance on the plant-products will be starved to death!

It is not inconceivable that the travelling supernova shell will impart enough momentum to the outer planets in the solar system to cause an imbalance, resulting in the removal from the sun's influence of planets like Pluto, Neptune and Uranus. It might even strip off the rings of Saturn, shower the giant planet Jupiter with enough material to make it shine like


Supernova
Shock wave
Penetration of shock wave
Protosolar cloud
Compression of protosolar cloud
Formation of star systems

(Continued on p. 67)

How much do you know about TEXTILES?


THE KING HAS NOTHING ON..!
M

The history of cloth-making can be traced to prehistoric times and can be said to have had a close relation to the progress of human civilisation, for, of all living things, man alone uses cloth to cover and decorate his body. Today, the textile mills have many interesting terms and expressions which many of us who use their 'finished' products do not often know. Given below are a few of them. Tick off the *best* response from the three alternatives given with each. After that turn the page for the correct answers.

1. **Staple fibres:** A. Edible fibres. B. Fibres cut into definite lengths. C. Long fibres.

2. **Union fabrics:** A. Two fabrics stuck together. B. Fabric containing a union of eight fibres. C. A fabric woven from warp and weft yarns made of different fibres.

3. **Mercerising:** A. Process carried out on cotton to decrease its strength. B. Process carried out on cotton to increase its strength. C. Process carried out on cotton that does not affect its strength.

4. **Count of yarn:** A. Number of yarns in a fabric. B. Number of fibres in a yarn. C. Expression of the fineness of yarn.

5. **Regenerated cellulosic fibre:** A. Fibre made from cellulose after dissolving it in a suitable solvent and then forming filaments. B. Fibre made by destroying cellulose and reforming it in a fibre from. C. Fully synthetic fibre.

6. **Heat setting:** A. Process to harden fabrics using hot water. B. Process to store heat in a fabric. C. Process where a synthetic fibre fabric is heated to high temperatures keeping its dimensions fixed.

7. **Softening of textiles:** A. Beating fabrics mechanically to soften them. B. Process in which some chemicals are deposited in (or reacted with) the fibres of a fabric to give it a soft touch. C. Process of heating fabrics to soften them.

8. **Blended fabrics:** A. Fabrics woven from warp and weft yarns, where both are made from mixed fibres. B. Multi-coloured fabrics. C. Fabrics fused together with an adhesive which will not separate even if washed.

9. **Denier:** A. A Danish fibre of great strength. B. A unit expressing the fineness of yarn. C. A term expressing length of yarn.

10. **Carrier dyeing:** A. Dyeing that is carried out by traditional methods only. B. A dyeing process in which a chemical 'carrier' is used to carry the dye into the fibres. C. A dyeing process in which only blue dye is used.

11. **Carbonised fabrics:** A. Fabrics which are coated with fine particles of carbon. B. Fabrics which are over-heated to convert them partly to carbon and hence to lend a black shade. C. Polyester-cotton blended-fibre fabrics processed to dissolve completely the cotton component.

12. **Fire-retarding treatment:** A. Process that gives fabrics resistance to burning. B. Process that makes fabrics warm. C. Process that makes fabrics fire-proof.

13. **Discharge printing:** A. Process for colour printing. B. Process for dischargin printing pastes through a screen on to the fabric. C. Process that produces a white design on a coloured background.

14. **Fluorescent brighteners:** A. Substances which glow in the dark. B. Substances used to make white clothes whiter and bright clothes brighter. C Detergents used in washing clothes.

15. **Padding machines:** A. Machines padded at certain parts so that the fabrics are not damaged in passing. B. Machines used to apply solutions of dyes or chemicals uniformly to fabrics and squeeze out any excess solution. C. Machines used to make thick cushion-like cloth.

16. **Finishing of fabrics:** A. Damaging the fabrics by faulty processing. B. Various processes carried out to impart certain desirable properties to the fabrics. C. Processes carried out by tailors before stitching fabrics into garments.

17. **Antistatic agents:** A. Chemicals which can make a fabric sell fast in the market. B. Chemicals which are not static, but move about when on a fabric. C. Chemicals which do not allow static electrical charges to accumulate in synthetic-fibre fabrics.

18. **Sublimation fastness:** A. Property of a fabric by which it does not sublime when pressed with a very hot iron. B. Property of a dye present on a fabric by which it does not sublime when pressed with a very hot iron. C. A property which is neither of the fabric nor of the dye.

19. **Transfer printing:** A. Process where a design first printed on paper is transferred onto a fabric. B. Process where a printing paste is transferred onto a fabric using screens. C. Process where the printing paste is transferred onto the fabric via printing blocks.

20. **Water-repellent fabrics:** A. Fabrics from which water will bounce off. B. Fabrics which do not allow water to pass through them. C. Fabrics which allow water to pass through them only with great difficulty.

(Continued from p 56)

a star, and, after causing the biological havoc on earth, arrive at Venus to bare its surface by dispersing the clouds in which the planet is always shrouded!

During the course of its journey, the rapidly travelling shell may encounter a gas cloud which would feel the impulsive pressure of this outburst and begin condensing into a system of stars. New stars will be born in the vicinity of the sun, but

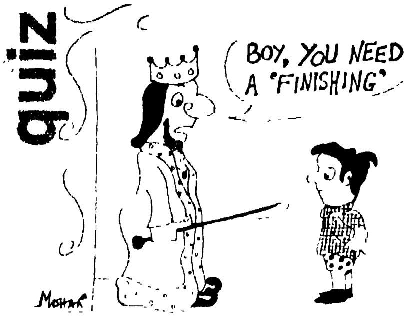
We have come into existence in the aftermath of a visiting supernova that is believed to have caused the formation of the solar system. It thus seems that the elements like carbon, nitrogen and oxygen, which are so vital for our life processes, and the iron in our blood and the calcium in our bones were probably cooked, long before our earth was born, in a dying star. Assuming that, over the ages, the human race in its wisdom manages to survive the nuclear and biological warfares, it will indeed be a pity if the violent death of another star in our neighbourhood should eventually be responsible in extinguishing the beautifully organised biological and chemical world of this planet. Was this what the poet T. S. Eliot had in mind when he wrote: "In my end is my beginning... In my beginning is my end"?

S. M. CHITRE

Prof. Chitre is with the Astrophysics Group at the Tata Institute of Fundamental Research, Bombay.

NEXT MONTH

- Low-cost housing — a special 24-page study
- Communicating through codes
- Heat adds to fatigue
- The why of a murder
- Helium probe and the earth's secrets


quiz
BOY, YOU NEED A 'FINISHING'
Mohan

The Answers

1. — B: Man-made fibres like rayon, nylon and polyester are first made in the form of long, continuous filaments and cut into 'staple fibres' of standard length ranging from 2.5 cm (1 inch) to 22.5 cm (9 inches). Cotton, wool, linen, etc (but not silk) are naturally staple fibres. The average length of the fibres is called the staple length. Different staple fibres are mechanically mixed in various proportions and spun into yarns to give blended-fibre yarns. For example, polyester and cotton fibres are mixed in the ratio 67.33 to get the blended-fibre yarns, which are then woven into cloth; often sold with such names as Terrycot or Polycot. The component fibres in a blend should have about the same staple length.

2. — C: A fabric is made from warp and weft yarns. But when warp and weft yarns are made of different fibres, for example nylon and viscose, the resulting fabric is called a union fabric. Generally, the stronger of the two fibres is used in the warp direction and the weaker, for the weft.

3. — B: This process, named after its inventor John Mercer of England, consists essentially in treating cotton (yarn or cloth) with a strong (24 per cent) solution of caustic soda, generally at low temperatures (around 20°C) for a short time while keeping it under stretched conditions (otherwise it shrinks considerably). After that it is washed, also under stretched conditions. The resulting (mercerised) cotton, with its increased strength, lasts longer. In addition, the material acquires good lustre, which unmercerised cotton lacks. The mercerising process also increases the dye susceptibility of fibres.

John Mercer

4. — C: Cotton yarn is available in the form of 'hanks' (continuous yarn wound in a circular fashion, folded into half and twisted against itself). Each hank generally contains 840 yards (768 m) of yarn. The number of such hanks in a pound (2.2 kg) is the count of the yarn. Obviously, as the count of the yarn increases, the diameter decreases, or its fineness increases.

5. — A: Cellulose occurs in nature in fibrous (cotton, linen, jute, etc) and non-fibrous (bark of wood) forms. Fibrous cellulose is directly used in the manufacture of yarn. Non-fibrous cellulose is first extracted from wooden logs, purified and converted into thin sheets, called wood pulp. This purified cellulose is dissolved with the help of caustic soda and carbon disulphide. The resulting solution is pumped into a solution of sulphuric acid (with some special chemicals added) through a spinnerette containing a number of fine holes. The cellulose is regenerated into continuous fine filaments (as many filaments are formed as there are holes in the spinnerette). All these filaments are bundled together into a 'multi-filament' yarn, called viscose rayon.

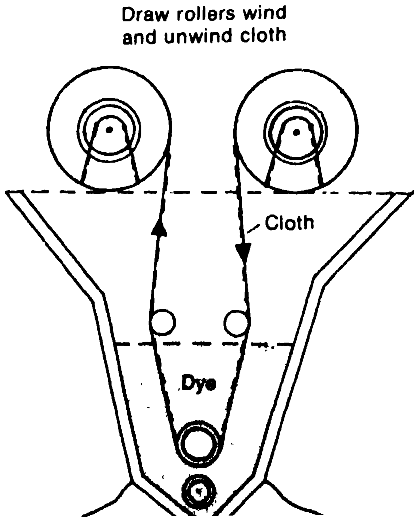
6. — C: Synthetic fibres like polyester and nylon are called thermoplastic fibres—they soften when heated to high temperatures and melt at still higher temperatures. Thus, polyester fibres which soften in the range 200° to 220°C melt at 250°C. When polyester fabrics are held in position at 200° to 220°C for a short time and then cooled, they acquire the property of dimensional stability that helps keep off creases or wrinkles. In fact, when deliberate creases or pleats are set in the fabrics at 200°C and cooled, they become permanent at all lower temperatures and can be removed only by using an iron at 200°C or higher.

7. — B: Cotton fabrics, which are generally not soft to touch, can be made so by using certain softening agents. There are such agents producing (1) temporary, (2) semi-permanent, and (3) permanent softening effects. Water-soluble softening agents, having no affinity for the fibres, are mechanically deposited in the fabric to get a temporary softening. If the treated fabric is washed, the softening is easily removed. There are also certain water-soluble and water-insoluble softeners, which get deposited in the fabric and form a loose complex with the fibres, thereby reducing their solubility in water. Since all of it cannot be removed, the softening produced is semi-permanent. Finally, there are reactive softeners, which can be chemically reacted with the fibres, giving a permanent softness which is unaffected by washing.

8. — A: When two or more fibres in the staple form (see **1** above) are blended together uniformly and spun into yarns, we get blended-fibre yarns. Fabrics made from this are called blended-fibre fabrics. Blending of fibres is done to get the advantages of the component fibres and to mask their disadvantages. Thus in polyester-cotton blended-fibre fabrics, the advantages of cotton (its property of good moisture and perspiration absorption) counteract the poor moisture absorption characteristics of polyester fibres, while the higher strength of polyester fibres prolongs the life of the blended product.

9. — B: The fineness of diameter of man-made fibre yarns like rayon, polyester or acrylic is expressed in 'deniers'. It is defined as the weight in grams of 9,000 m length of the yarn. Thus 9,000 m of a 40-denier yarn weighs 40 gm. In the case of an 80-denier yarn, 9,000 m of the yarn weighs 80 gm, it being obviously thicker (or coarser). Hence, in contrast to 'count' (see **4** above), yarns become coarser as their denier value increases. The present trend is to replace denier by another term 'tex'. The tex of a yarn is the weight in grams of 10,000 meters (instead of 9,000 meters) of the yarn.

10. — B: Dyeing of natural fibres (like cotton, wool, silk, etc) is done by dipping the fibres, in yarn or fabric form, in the solution of a dye in water and heating, if necessary, generally until it boils, the dyeing being continued at the boil. Most of the machines used in dyeing natural fibres are designed for dyeing at temperatures of up to 100°C. However, most synthetic-fibre materials, with their very compact structure, cannot be effectively dyed at this temperature. So certain chemical 'carriers' are added to the dye solution which open up the fibre structure and create big voids into which the dye molecules enter and complete the dyeing. The process is called carrier dyeing.

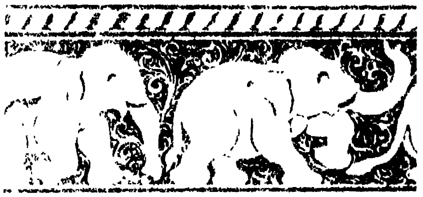


The common "jigger" shown diagrammatically here lets the cloth pass to and fro many times through the dye solution

11. — C: India is perhaps the only country to produce carbonised fabrics by this unique process. In this, polyester fibres are first blended with fine cotton (ratio 2:1), spun into yarn and woven into cloth using the blended-fibre yarn as both warp and weft (see **8** above). The resulting cloth is passed through 70 per cent sulphuric acid, when the entire amount of the cotton component is *destroyed* and removed, leaving behind the polyester component. The cloth now contains only the polyester fibres (and hence is a 100 per cent polyester fabric). It loses one-third of its weight, becoming softer and more transparent. The '100 per cent polyester saris' are made by this process.

12. — A: When certain boron, nitrogen and phosphorus compounds are applied to fabrics, they may chemically react with the fibres after getting deposited in them. When ignited, they burn reluctantly and can be extinguished. This treatment does not make the fabric fire-proof (fire-proof implies that when such a fabric is thrown in fire, it refuses to burn). It only makes the fabric fire-retardant or flame-retardant. In some cases the fabric may char, but not burn. If the chemical used is water-soluble, the flame-retarding effect is gradually lost during successive washes.

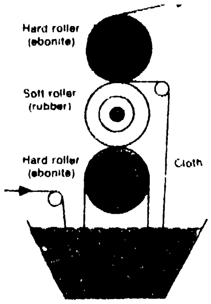
13. — C: A printed effect in one or more colours is produced on a fabric by using printing pastes containing dyes and certain other ingredients. This gives a coloured design on a white background and is called direct printing. In another style of printing, the cloth is first dyed uniformly with a dye. A chemical which can bleach (or destroy) the dye is then printed in the form of a design. This produces a white design on a coloured background, and is called white discharge printing (the chemical destroys or discharges the dye at the printing area). When a dye, which is fast to the destroying action of the chemical, is also mixed with the chemical and printed on the dyed cloth the chemical destroys the dye present on the cloth at the printed areas. Meanwhile the dye which is printed along with the chemical is not destroyed, but is fixed at the printed area. This produces a coloured design on a differently coloured background and is called coloured discharge style of printing.



Discharge printing appears thus

14. — B: Fabrics can pick up these chemicals (commercially known under the trade names of Ranipal, Blankophor, Pontamine White, Leucophor, etc) from their solutions in water. They have the property of absorbing invisible ultraviolet light from sunlight, and converting it into visible light. The phenomenon is called fluorescence, and so these chemicals are called fluorescent brighteners. Fluorescence is effective only when ultraviolet light falls on them. Conversion and re-emission of light is instantaneous.

15. — B: A typical padding machine consists of three rollers (two hard and one soft) placed vertically one above the other, the soft roller being kept at the centre. A trough containing the dye solution is positioned below the rollers. The fully opened cloth is passed into the solution, squeezed between the rollers, dipped in the solution again, squeezed a second time and taken out. The operation is called padding. Due to the heavy pressure exerted on the cloth while passing between the hard and soft rollers, the dye solution is uniformly deposited in the fabric. The padding machine is also used in other processes, especially where certain chemicals have to be deposited in the fabrics.



Working of a typical padding machine

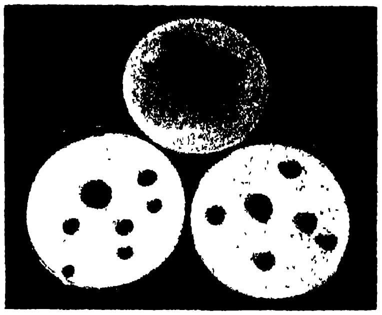
16. — B: Finishing is a final process carried out on bleached or dyed or printed fabrics to impart certain desirable properties to them (which may be purely temporary, lasting for only one wash, semi-permanent, or permanent), and to increase its sales appeal. Softening, making it crease-resistant, water repellent, rot-proof, flame retardant, shrink-proof, etc are some of the many finishing processes.

17. — C: The water-absorption power of synthetic fibres, especially polyester, is very poor. In fact, polyester fibres absorb only about 0.4 per cent moisture from the atmosphere, compared to the 7 to 8 per cent absorbed by cotton fibres. When dry polyester fibres are rubbed against any surface, static electricity is generated which gets accumulated by virtue of its low moisture content. The accumulated static electricity causes inconvenience to the weaver and also attracts dust particles from the atmosphere. Collars and cuffs of shirts, areas constantly rubbed against the body, generate greater static electrical charges and get dirty fast by attracting dust. In order to overcome this problem, chemicals called antistatic agents, are applied to polyester fabrics so that when the static electrical charges are generated, subsequent rubbing causes them to dissipate rather than accumulate.

18. — B: There is a class of dyes, called disperse dyes, used to dye man-made fibres like polyester, nylon, cellulose acetate rayon, etc. These dyes are not generally soluble in water; they are powdered to very fine particles and dispersed in water in the presence of a dispersing agent. After dispersion, they are used for dyeing synthetic fibres. Water-soluble dyes, which are used on cotton, wool, silk, etc melt at higher temperatures compared to the disperse dyes, some of which melt even at 150°C. When polyester or nylon garments dyed with such dyes are ironed with a very hot iron, some amount of the dye may sublime off. In this case, we say that the dye has poor sublimation fastness. Good dyes, intended for dyeing or printing on polyester and nylon fabrics, should have high sublimation fastness.

19. — A: This is a process successfully practised for printing on polyester fabrics. Initially, a multi-coloured design is printed on paper using special inks (containing suitable dyes). The resulting paper roll is called the transfer printing paper. This roll is unwound, the paper is placed in contact with the polyester fabric, and heat and pressure are applied. The dyes present on the paper sublime on to the polyester fabric and get fixed in it.

20. — C: Various degrees of water-resistance can be imparted to fabrics. Thus, when a solution of rubber or polyvinyl chloride (PVC) in a volatile solvent is applied and the solvent allowed to evaporate, a continuous layer of the rubber or PVC is formed on the fabric so that water (even air) cannot pass through it. This process is called water-proofing and is essential for rain coats. On the other hand, when cotton fibres are treated with certain chemicals, like silicones, the chemicals react with individual fibres present in the fabric, making the fabric repel water. However, here air can pass through the fabric. If water is placed in a cone prepared from the treated fabric and kept for 18 to 20 hours, very little water passes through the cone. This effect is called water repellency.



Cotton fabrics treated with water-repellents (below) retain water drops while untreated sample (above) absorbs water. Photo taken 10 min after placing the water drops containing a dye

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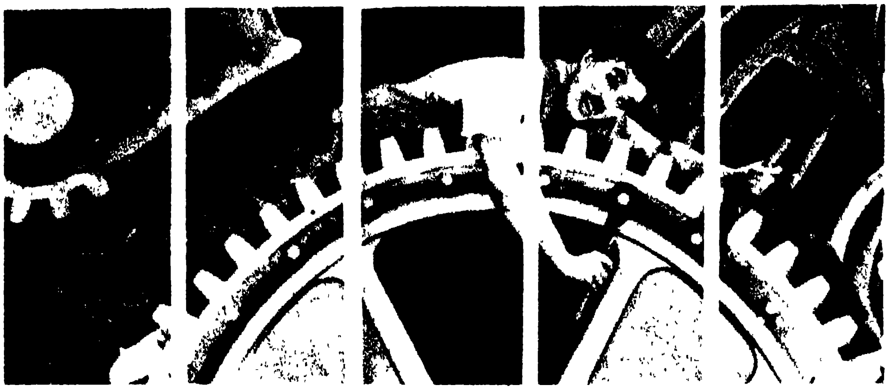
Limits to human performance

The physical limits to our working capacity pose a challenge to designers

Krish Pennathur



THE human body is indeed very versatile. What a range of activities a man may be engaged in, in the course of a working day? He may push buttons, twist and turn knobs, manipulate wheels and levers, carry weights, scan charts, remember, interpret and evolve ideas. He also sees, hears, tastes and smells. There seems no limit to the list of his capabilities, and the number of new functions he can learn is endless. But there do seem to be limits to his working capacity—limits to the amount of weight that he can carry, or the rate at which he can push buttons. These limits may be imposed by his physical constitution, by the environment in which he works, or by the tools that he uses. Outside these limits, human performance markedly changes and affects efficiency. And that affects the work system.

This is why ergonomists (from the Greek 'ergon' meaning 'work' and 'nomos' meaning 'laws') today are busy identifying these limits. Their purpose is to help designers devise machines and working environments that would make the best of these human limits, thus ensuring more useful expenditure of the human energy. In order to suggest ways to reduce work loads, the ergonomist analyses the effects of an existing or a proposed work system on an operator.

Because the ergonomist's whole focus is on the human being, the task of expressing this in qualitative and quantitative terms is not as simple as with a mechanical device. When the body performs any work, a large number of muscles and joints come into play, resulting in variations in the efficiency of body functions. The variations may be between 10 and 30 per cent. Though this may lead to problems in tabulation, it also provides a tremendous opportunity to the ergonomist-designer: the challenge being to devise work situations, tools, machines and what have you, that help the person to perform at the upper end of his capacity. This would mean that three times as much useful work can be done for the same energy expenditure.

To facilitate the analysis of the inputs into and the outputs expected of the operator, ergonomists have classified the loads imposed during work into three groups—physical, perceptual and mental loads. Each of these can be further classified as 'static' and 'dynamic' loads, depending on whether, when human energy is expended, there is an associated change in posture (see Table 1 for some examples). Here we shall deal with only the physical loads.

Physical loads

A physical load is imposed whenever there is an expenditure of physical energy in the execution of a task. The energy expended may be measured in heat units (calories per unit time), or in work units (joules). Just as the many different muscles and joints vary in their functions and characteristics, so work must be distributed compatible with them. For instance, the large muscles, like those in the upper arm, thigh and shoulder, can exert considerable pressure. The small muscles, like those in the fingers, have limited strength, but contribute to human dexterity and speed.

If the force applied is continuous but does not involve an appreciable movement of any part of the body, it is treated as the static physical load. It leads to prolonged contraction of muscles, fatigue, tension and loss of efficiency. Static loads due to holding a needle ready for threading or holding a bottle into which a liquid has to be poured cause tremors. Such 'static reactions' cannot be reduced by being conscious of them. Instead, the use of a visual reference, or a support for the body or limb, helps to reduce the tremors. On the other hand, the body movements associated with dynamic loads lead to alternate contraction and relaxation of muscles and, hence, are more tolerable than static loads. The aim then is to eliminate or reduce

Table 1
Examples of static and dynamic loads

Static	Dynamic
Physical	
a. Standing rigidly to attention	a. Walking
b. Continuously pressing a button	b. Fetching and carrying loads
c. Sitting or lying without change of posture	c. Any activity associated with the movement of one or more limbs
Perceptual-Visual	
a Gazing vacantly	a. Watching the traffic signal
b Watching a radar screen for an enemy aircraft	b. Timing by a stop watch
c Focussing on a static source of light	c. Gauging the temperature of a heated piece of steel
Aural	
a. Continuous background noise	a. An alarm clock going off
b. Hum of a fan	b. An air raid siren
Mental	
a. Remembering to take action	a. Reaction to perceptual inputs
b. Memorising the arithmetic tables	b. Evaluating
c. Recall of a passage read long ago	c. Creative thinking or writing

Table 2
The average strength of the arm for various movements in sitting posture
Maximum strength (kg)

Movement (In descending order of strength)	Angle of the arm 0°	30°	60°	90°	120°
Pushing forward	23.0	19.0	16.0	16.0	15.0
Pulling forward	24.0	26.0	19.0	17.0	11.0
Pushing up	6.5	8.0	11.0	9.0	9.0
Pulling down	7.5	9.0	9.5	9.5	8.0
Pulling out (side)	6.5	6.8	6.8	7.1	7.3
Pulling in (side)	9.0	9.0	10.0	8.0	9.0

Table 3
The average maximum arm strength for standing posture as a percentage of body weight

Position of outstretched arm	Pushing %	Pulling %
Vertically up	130	100
Forward, horizontal	15	10
Sideways, horizontal	10	10
Vertically down	100	120

All the data used in this article is based on the Indian socio-industrial environment.

static loads.

Whether we are sitting or standing, the amount of force that we exert depends on three factors: our physical strength, the posture adopted by the body during work, and the direction in which the force is applied. The most effective body posture would be such that the force is exerted by the body weight rather than directly by the muscle or joint. The direction of force is least effective if the limb or any other part of the body during work is moving against the force of gravity.

Strength of limbs: The limbs are capable of applying a great deal of force momentarily. The force that can be sustained over a minute can be as low as 25 per cent of the momentary peak, and only 10 per cent if prolonged further. The maximum force that can be exerted by the arm is when it is outstretched and the control to be applied is in front of the operator. Sixteen kg by hand or 27 kg by foot is the maximum force that can be exerted for a prolonged period before fatigue sets in.

The maximum force that the arm can apply is when it pushes forward. From experience the saw has been designed so that the maximum thrust of the carpenter is when he pushes the saw away from himself. In such a movement the body weight supplements the movement of the arm. Table 2 compares the arm strength in various movements while sitting, and Table 3 compares them while standing.

The right hand of a right-handed person can exert a maximum dynamometric pressure of 40 kg while the maximum force that his left hand can exert is 5 kg less. The prolonged pressure that can be exerted by either hand is about 60 per cent of the maximum momentary pressure that it can exert. Employing the fingers alone, and not the arm, demands less energy per specific amount of control force applied. Naturally, the amount of force that can be exerted increases when more parts of the limb are used.

When a wheel or knob has to be rotated or turned, the force applied is greatest when the forearm is at 90° from the upper arm and is least when the angle is reduced to 30° or less. If we are standing, cranks and levers can be turned most efficiently if they are at the shoulder level, and in the sitting posture, at the elbow level.

Table 4
Leg force — maximum thrust in kilograms

Angle of leg	Thrust (Kg)
10° above horizon	155
Horizontal	180
30° below horizon	170
45° below horizon	145
60° below horizon	115
Almost vertically down	80

Lifting: The weight that can be lifted depends on the parts of the body used. When only the extensor muscles of the arm are used, the lifting power is about 20 kg, while the biceps increases the load to 25 kg. But the maximum weight that the body can support is when the back is used. It is as much as 120 kg for very short periods. Hill and mountain porters have on their own discovered that the maximum weight of luggage they can carry up an incline is when the load is fairly evenly distributed over their backs. If the head is properly cushioned it can support 90 kg for short durations and 45 kg for longer durations.

Leg strength is next only to postural strength. The legs, bent at the knees to start with, can pull in a vertical direction a maximum of around 200 kg. However, great care should be taken in prescribing the upper limits to weights to be lifted. A person should always bend from the knees and not from the back. Not only can the back be seriously damaged but the likelihood of hernia can also be high.

Sensitivity: Many work situations demand an accurate amount of force to be applied. At threshold levels (below 200 g for hand-operated adjustments), the sensitivity for discrimination of an applied force is low. In the middle ranges, the error in discriminating the force required to be applied is small. Although in the higher ranges (above one kg for hand adjustments) the 'error' to the 'requisite pressure' ratio is small, the absolute error can be large. In order to make up for the lack of adequate sensitivity at the threshold levels and to guard against large absolute errors at higher levels, the reacting force of the control can be modified by incorporating additional resistance in them to bring the pressure required to be applied within the middle ranges.

Human motor activities: In some motor activities, we are able to perceive the progress of achievement while applying energy. An activity, for instance tuning a radio, that provides such a feedback is termed as a 'closed-loop' system. In an 'open-loop' system, there is no perceptual evidence of the progress during the performance of an activity. Some examples of the open-loop system are: adjusting a thermostat, or comparing weights of objects without any metering system. In conditions of extreme fatigue, the motor nerves fail to function and may not transmit any signals. In normal conditions of fatigue, more than moderate stimulus is needed to energise the motor nerves.

Dr. Pennathur is currently coordinating the Commonwealth Research Programme on Standard Rate Performance of Workers. He is also engaged on certain facets of ergonomic research based on the Indian socio-industrial environment.

Tell Us...

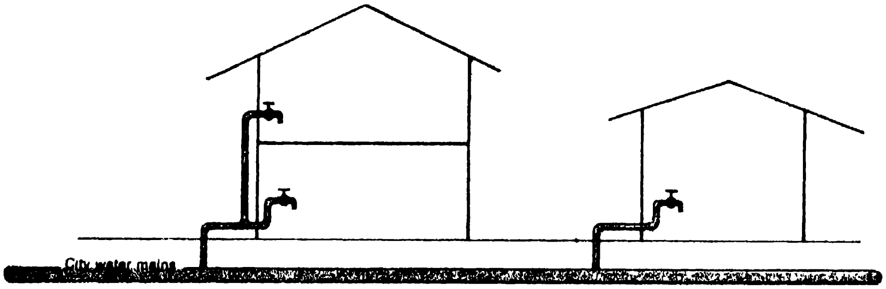
.... whether water pipes make a good electrical earthing?

MANY people, including engineers and scientists, believe that the water pipes in the bathroom make a reasonably good earth. Do they really? In the present-day construction practice, this is a totally wrong assumption and can lead to fatal accidents.

Many do-it-yourself manuals on radio, TV, etc may have also told you that to get a good and safe earthing, just connect the earth pin of your radio to a tap in your bathroom. This is not always true.

If you live in a small town, where the water pipes in your home come directly from the main pipe, your pipes could provide a workable but unsafe earthing. But not in modern multistorey buildings in cities, where the water supply comes from an overhead tank.

Fig. 1: Bungalow-type houses where water comes directly



Most electrical appliances that are available today, you must have noticed, have a green 'earth' wire that originates from the conducting body of the appliance. This green wire is connected to a good earth through the thicker and longer earth pin of a three-pin plug. This is a safety measure which maintains the body of the appliance at the earth voltage and thus eliminates the possibility of getting a shock.

Any faulty appliance in which a live wire had been 'shorted' will cause the fuse to blow, provided the earthing system is good. But if the earthing is bad, this condition could bring the earth wire to a high voltage without the fuse blowing. And if a water tap has been connected to this earthing, any one who may touch a water tap in any flat in the building could get a severe shock.

In a bungalow-type house with only a floor or two, the city water pipe is generally buried in the ground before it reaches the house (Fig. 1). If you connect the green earth pin lead to a tap in your home, the pipes buried underground just outside can provide some kind of electrical earthing. Even so, rust that may accumulate at couplings between pipes, or any other factor, may cause the continuity of the earthing to break. This is a potentially dangerous situation.

But if you live in a flat in a modern multistorey building, any attempt to obtain an earthing through the water tap could be futile, even fatal. In such buildings (Fig. 2), water is supplied to flats from an overhead storage tank. Water from the main city supply is fed into the overhead tanks either directly or lifted from a tank on the ground by means of booster pumps. What is to be noted here is that the pipeworks connect the overhead tank and the different flats in the building, they *do not* get an earth connection.

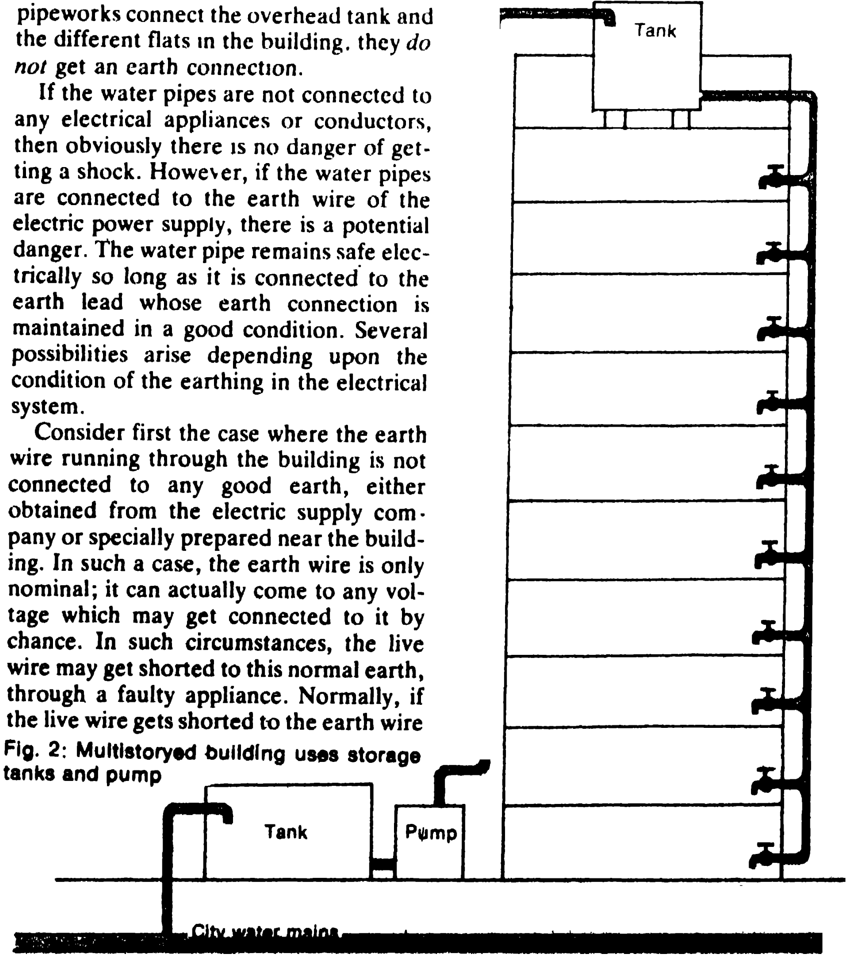
If the water pipes are not connected to any electrical appliances or conductors, then obviously there is no danger of getting a shock. However, if the water pipes are connected to the earth wire of the electric power supply, there is a potential danger. The water pipe remains safe electrically so long as it is connected to the earth lead whose earth connection is maintained in a good condition. Several possibilities arise depending upon the condition of the earthing in the electrical system.

Consider first the case where the earth wire running through the building is not connected to any good earth, either obtained from the electric supply company or specially prepared near the building. In such a case, the earth wire is only nominal; it can actually come to any voltage which may get connected to it by chance. In such circumstances, the live wire may get shorted to this normal earth, through a faulty appliance. Normally, if the live wire gets shorted to the earth wire with proper earthing, the fuse will blow. But in this situation, the fault condition will only bring the so-called earth wire to live potential, and the fuse will not blow. One would get a severe shock on touching a water tap in this condition.

If the earth wire is connected to a good earth the possibility of getting a shock reduces, but is not altogether ruled out. The reason for this is as follows: if the water pipe is properly connected to the earth wire and a faulty appliance brings the live wire in contact with the earth wire an excessive short-circuit current will flow and the fuse will blow, if the fuse itself has not been tampered with. This will offer protection. But if the fuse has been tampered with, the short-circuit will burn the wire or cause some other damage to the installation; it is not expected to give an electric shock.

It is, however, possible that the earthing had developed some fault over a period of time. In this case, the earth wire is only nominal, and the eventualities discussed in the previous paragraph will apply. The point to emphasise is that the reliability of the earth wire cannot be taken for granted; it must be checked periodically. And even if the earthing in a building is in a good condition, the particular socket into which the faulty appliance is plugged may not be getting properly connected to the earth. In this case, though the problem is localised to one particular socket, water pipes in the entire building may come to a live potential through that appliance.

Fig. 2: Multistoryed building uses storage tanks and pump



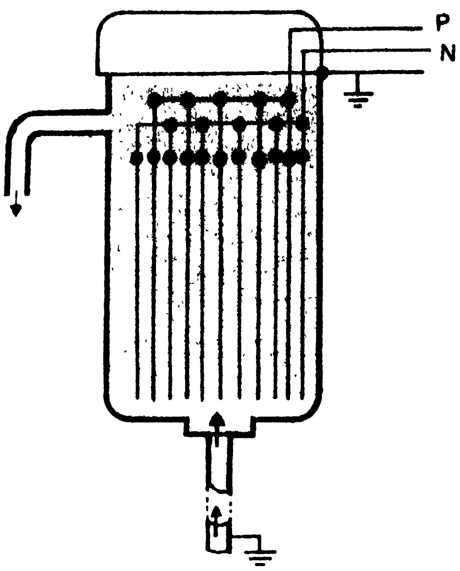


Fig. 3 Plate-type geyser

It is important to say a word here about the plate-type geysers (Fig. 3), which are particularly risky. The water flows into the geysers, when the power supply is on; the electric current flows from the phase plates to the neutral plates through the water which gets heated directly and quickly. Normally, the outer plates are connected to the neutral lead and the inner plates to the phase lead, which introduces a measure of safety However, if these connections get interchanged due to faulty wiring of either the wall socket or the geyser plug, things could be dangerous. One may get an electrical shock by touching the geyser in such a case because of the large leakage current which flows to the body of the geyser and brings it to a high voltage if the earthing is not good.

P. J JOGLEKAR

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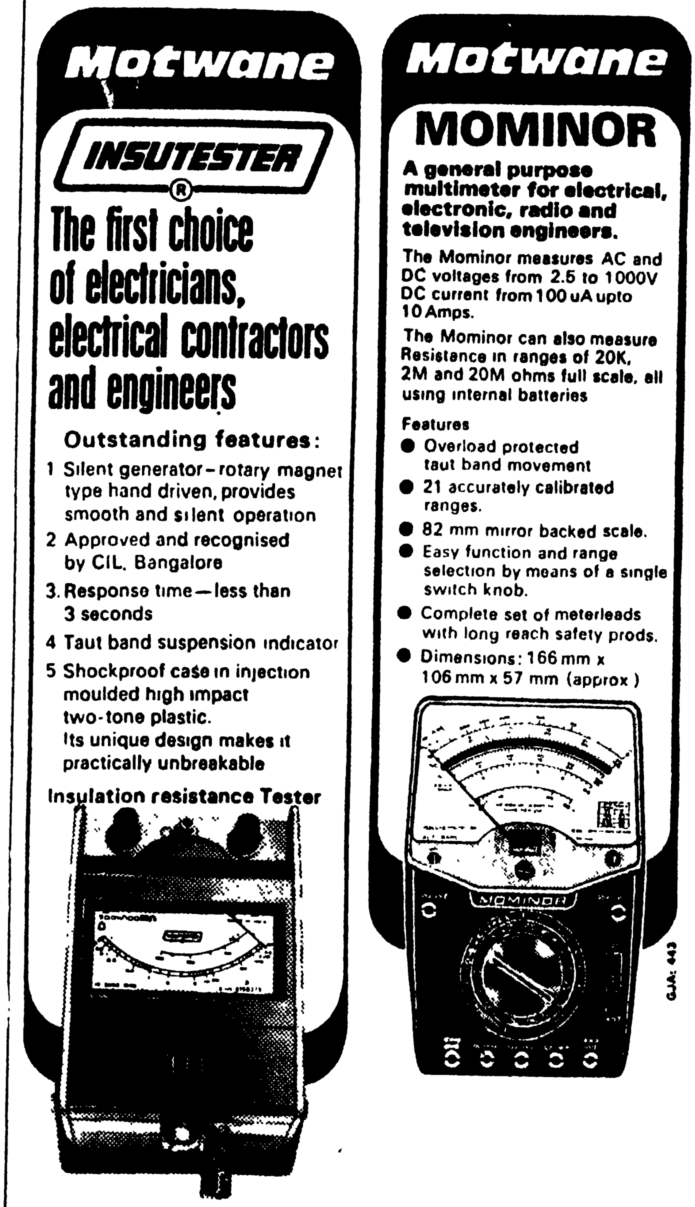
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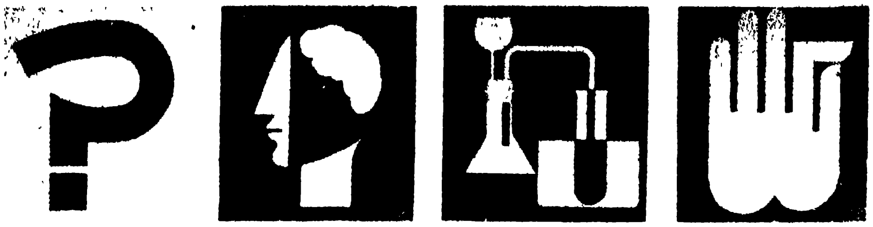


The method of science
3

To recapitulate: The method of science allows us to obtain answers to questions; it consists of four distinct steps. Steps 1 and 2 — the framing of a question and the formulation of a hypothesis — were discussed last month. Steps 3 and 4 are discussed here.

Text©P M Bhargava

STEP 3 IN THE METHOD OF SCIENCE

The Experiment

The experiment must have one of the following objectives: to find an answer to a question or to prove or disprove a hypothesis.

The importance of the unexpected

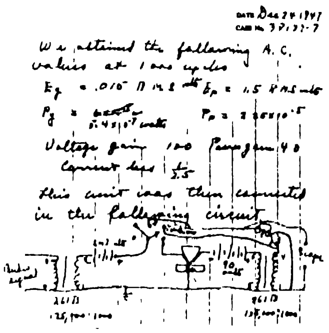
An unexpected observation can lead to an important discovery: remember, how penicillin, was discovered by Fleming!

In 1928, Alexander Fleming made the unexpected observation that there was no growth of bacteria around the area where a mould (which he called penicillium) had accidentally settled on a dish on which the bacteria were growing. He pursued this unexpected observation and discovered penicillin— the substance made and secreted by the mould and responsible for killing the bacteria around the mould

The original culture plate on which the action of penicillin was observed by Fleming

The experiment must be planned and carried out with care. To do an experiment:

★ write down each step in the experiment;



Dec 24 1947

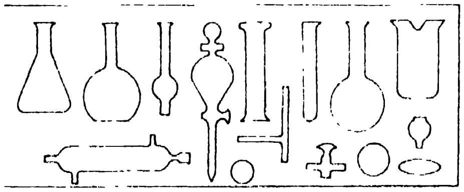
We attained the following A.C. values at 1000 cycles

Voltage gain 100 Power gain 40

This unit was then connected in the following circuit

Logbook entry recording the discovery of the transistor effect. The entry was made by Walter Brattain, who, along with his co-workers, John Bardeen and William Shockley, won the 1956 Nobel Prize in physics for this discovery and their research in semiconductors

★ collect all the material needed;



★ record all the observations made, immediately and carefully, paying attention to the smallest detail;

★ repeat the experiment, whenever possible, to ensure that the observations you made and the results you obtained are reproducible. If they are not, you were careless one time (or both the times), or had failed to notice a new source of error such as a newly-developed fault in the instruments you used;

★ record everything—expected or unexpected—whether you wished it to be so or not;

★ results of two experiments, carried out under identical conditions, should be identical.

Photos. M. Hasan/Kaiser Jamil

STEP 4 IN THE METHOD OF SCIENCE

The Answer

The answer you arrive at could be in the form of a fact, a statement, or a generalisation.

Hemophilia and history

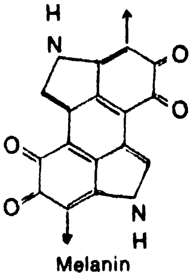
Hemophilia is an inheritable disease which apparently altered the course of history. This happened because Queen Victoria was a carrier of this disease.

Queen Victoria and her husband, Prince Albert, were prolific parents and their offspring married into almost all the royal families of Europe. The disease was thus carried into these royal families, and led to the death of male descendants whose survival could have changed the course of events in Europe.

For example, Alexis, the only son of Nicholas II (the Czar of Russia, to whom one of Queen Victoria's granddaughters was married) was a hemophiliac, and because of this the Czar and Czarina relied heavily on the corrupt and cunning monk, Rasputin, who promised a cure for Alexis. This strange relationship caused a rapid decline in the Russian court. Alfonso XIII, the eldest son of the last King of Spain—and a great-grandson of Queen Victoria—also died of hemophilia. The Russian and the Spanish dynasties can, therefore, be said to have "bled to death" because they ended with uncrowned successors—the heirs-apparent—who died of hemophilia. (See chart below).

A generalisation—usually stated as a law—is derived from a set of experiments which confirm a single hypothesis of general applicability, or a group of related hypotheses.

An example:



Melanin

★Observations

1. Our skin and hair, and the iris of our eyes, contain a pigment called melanin. The amount of this pigment varies from person to person; the more pigment we have, the darker would be our skin, hair and iris. Some individuals, however, totally lack this pigment; they are called albinos. They have an unusual appearance and can be easily spotted; their skin is pinkish white, their hair straw-coloured, and their eyes are specially sensitive to light. You may observe that one family has more than one albino.
2. It is common experience that after a small cut, the bleeding stops all by itself due to the formation of a blood "clot" at the site of the bleeding; the cloth blocks the cut and prevents any further bleeding. However, in some individuals the blood does not clot, and continues to flow out. Such individuals whose blood would not clot are called hemophiliacs. A hemophiliac may bleed to death from a small cut of the type which most of us would not even notice. In this case, too, we notice that a family may often have more than one hemophiliac.

★Hypothesis

Both albinism and hemophilia are abnormalities which could be hereditary.

★Experiments

1. To look for other albinos or hemophiliacs in the family of an albino or a hemophiliac.
2. To determine, by biochemical analysis, why an albino cannot make the skin pigment, and also why the blood of a hemophiliac does not clot.

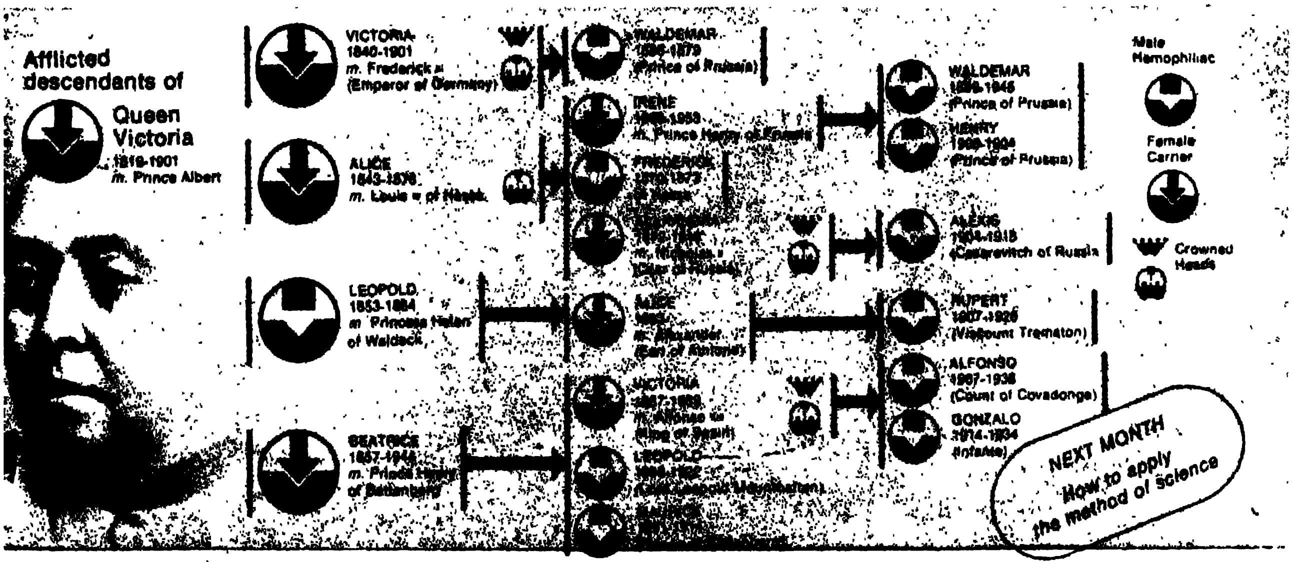
★Results

1. In the family of an albino or a hemophiliac other albinos or hemophiliacs are generally found.
2. Albinos cannot make the pigment because they lack an enzyme (a biological 'catalyst')required for synthesising the pigment. A similar enzyme deficiency prevents the clotting of blood in hemophiliacs.

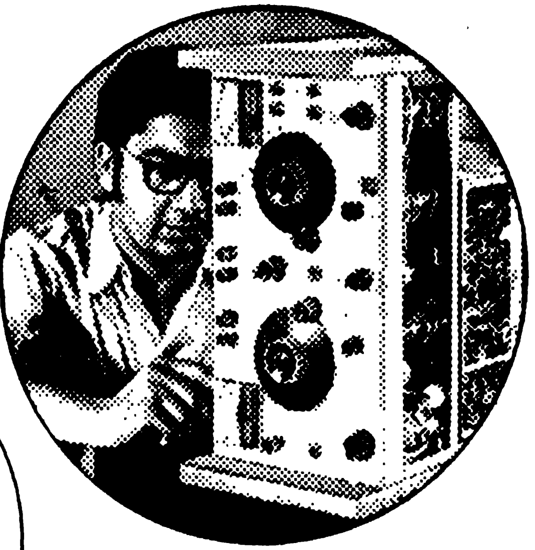
★*Generalisation*

An inheritable enzyme deficiency can cause an abnormality.

Queen Victoria, *(1)*, presiding over an 1894 gathering of European royal families. Numbers on the photograph identify some of Victoria's female descendants who were hemophilia carriers: 2 Beatrice, *3* Alexandra, *4* Irene, *5* Victoria)



NEXT MONTH
How to apply the method of science



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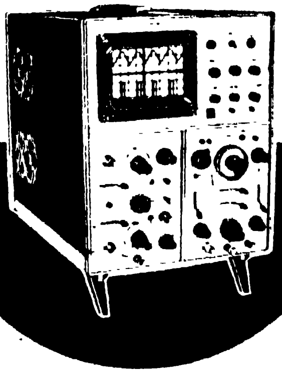
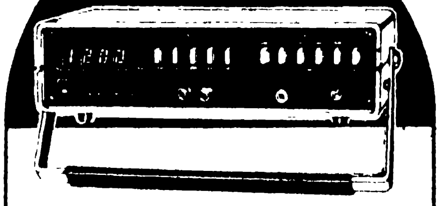
Dual Trace





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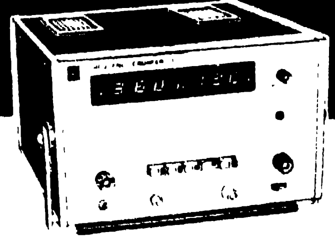

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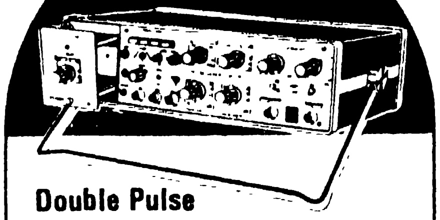

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Communications through computer networks

Computer network technology opens up exciting applications in several industries and public services

S. Ramani

RECENT developments in communications promise to banish distance as a barrier to information transmission. Computers performing communication functions can move pages of text from one city to another in seconds. And a user can carry on a conversation with a computer a thousand kilometres away, using a telephone line.

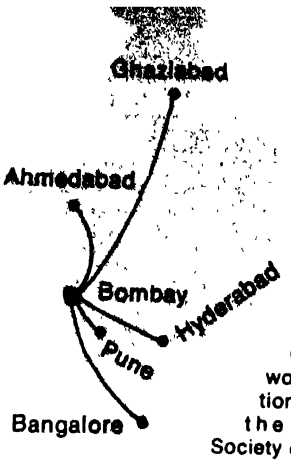
The computer network is a major technological development of the last decade. The 'eighties will see its wider use. A recent demonstration of this technology stressed India's capabilities in this field (see box below). Three groups from the UK and the US also demonstrated their network systems, using links set up by the Overseas Communication Service through their communication satellite system.

What are the basic ideas underlying these developments? How much of this is practical in India? What are the costs involved? What new services can we expect from the technology of computer networks?

Most modern developments in electrical and electronic communications are based on digital techniques—a fundamental advance in this field. Digital communication systems usually use electrical voltages (sometimes electrical currents) as *symbols*. For instance, -5 volts could represent the symbol *1* and +5 volts could represent the symbol *0*.

The common telephone sends a varying level of current, depending upon the pressure exerted on the microphone diaphragm by the incoming sound. But in digital systems, only two levels of voltage (in some systems, just two levels of current) are used. All information going on a digital pathway can be written as a sequence of 0's and 1's. For instance, the output from a computer going to another computer on a digital pathway could be like this: 0010011101011...

The symbols 0 and 1 can be handled by electronic circuits meaningfully. Circuits can detect a particular pattern of 1's and 0's as an *address* and respond to the following 1's and 0's appropriately. For instance, such circuits can help a communication device to accept messages beginning with its own *address;* other messages can be ignored. Such handling of patterns made of 1's and 0's is identical to the handling of information inside a computer. Using this basic digital representation, communication systems can take messages from one computer to another. Also, the work done by a communication system, say a telex exchange, can be done by a computer.



Computer network demonstration organised by the Computer Society of India, Posts and Telegraphs Department and Hindustan Teleprinters at the Networks 80 international symposium held in February in Bombay

Text transmission

Letters of the alphabet, numbers, punctuation marks, etc are collectively called *characters* by computer programmers. Each character is usu-

NETWORKS 80

The Networks 80 demonstrations held in Bombay recently illustrated a number of ideas. Two of these were remote access to computers and electronic messaging.

When computers are linked together by a packet-switching network, a user at a terminal can use either a local computer for his work or a remote computer. By typing in *Set host 20,* the user is given access to computer number 20. Everything he types is sent to computer '20' and its responses are sent back to him. By typing in *Set host 40,* the user gets access to computer number 40. In the Indian demonstration, host No. 40 was the computer at the Indian Institute of Science, Bangalore, and host No. 20 was a computer at the National Centre for Software Development and Computing Techniques (NCSDCT) in Bombay. A number of users at these two centres used each other's computers with great ease.

The computer user is unconcerned with the management of communications lines; this is done automatically by minicomputers performing the packet-switching function. As far as he is concerned, he is linked to the computer of his choice from the moment he gives the command. Since the mini computers performing communications management use a single telephone channel to carry the traffic of as many as ten users at a given time, remote access to computers is also economical. A user at a computer terminal usually needs 100 to 200 rupees of computer services per hour. An additional 10 or 20 rupees per hour could give him access to a connected computer a thousand kilometres away.

S.R.

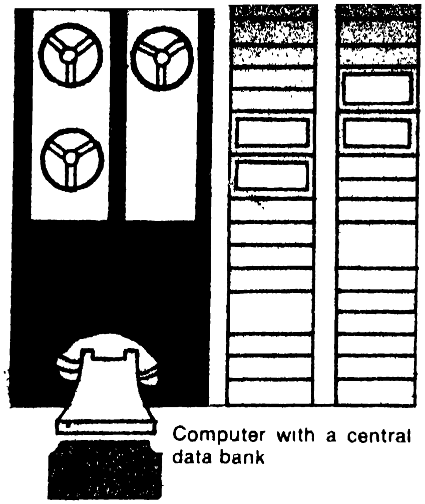
A messaging system developed at the NCSDCT was also demonstrated. The key features of this system are: (i) it accepts messages at any time and, using the store-forward principle, delivers them when possible; (ii) it can deliver messages to recipients at remote locations provided their computer is connected to the same network as the sender's computer; (iii) it uses a *password* system to ensure identification of the recipient before delivering the message; (iv) it provides for messages to be redirected (suppose you normally work with a computer in Bombay and have temporarily gone to Delhi, the Bombay computer can be instructed to send all messages received for you to Delhi); (v) it provides summaries, typed copies of messages (when requested), copies to be filed in the computer memory, etc; and (vi) it provides for reliable acknowledgements to be written by the recipient. The recipient can 'throw away' messages he has read or he can keep them, as he likes.

Every user of the messaging system leaves a secret 'password' of his choice to be safely recorded by the system. When he asks for his messages, he identifies himself with an account number. The system then asks for his password. Unless he can type in the correct password for that number, the system refuses to do any further work.

A user can tell the system that his routine messages can be made available to someone else (identified by his own user number and password), usually a colleague. The system will show messages to the colleague, but *not* let him throw away messages or change them.

Also, if a message is marked confidential, the system will show it only to the recipient, not the colleague.

P. SADANANDAN

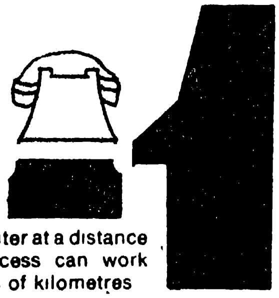


Computer with a central data bank

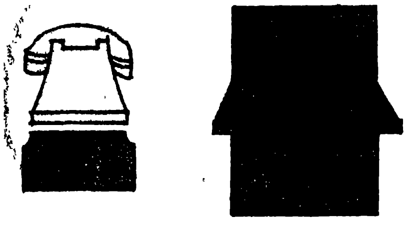
ally represented by a unique sequence of 0's and 1's. For instance, according to a popular scheme, the following codes are assigned to A, B, C, etc. digits and punctuation marks.

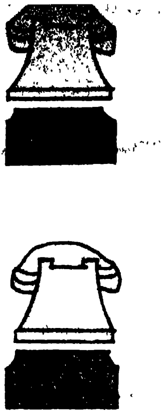
A	1000001	0	0110000	.	0101110
B	1000010	1	0110001	,	0101100
C	1000011	2	0110010	;	0111011
D	1000100	3	0110011	+	0101011
Z	1011010	9	0111001	)	0101001

Text, which is only a sequence of characters, can be entered into a computer using a *terminal*. Some terminals are essentially electrical typewriters. When you type on the *keyboard* of a terminal, it passes on the information to a computer in the form of appropriate patterns of 0's and 1's. The computer sends back a reply again in a suitable pattern of 0's and 1's. The terminal interprets the reply and types it out in a readable form. A special type of terminal is the video display unit (VDU) which does not use paper. It shows text matter on



Using a computer at a distance — remote access can work over hundreds of kilometres





a TV-like screen, using an electron beam to create readable images on its screen.

Computer memories can store text and messages (which are nothing but small pieces of text with a destination address in computer-readable form).

The question of cost

Most computer users assume that one needs very special cables, installed at a great cost, to send digital information from one city to another. But common telephone cables are sufficient for sending such data at reasonable speeds, up to 2,400 *bits* per second. A *bit*, short form of *binary digit*, is either a 0 or a 1. Since a character is, at the most, 8 bits long, one can send text at rates up to 300 characters per second on an ordinary telephone link. This corresponds to a page of SCIENCE TODAY every 25 seconds. Considering that subscriber trunk dialling (STD) costs only 15 paise per second from Bombay to Delhi, one can see the potential for text transmission systems. A small letter can go from one city to another in a fraction of a second for a fraction of a rupee. (One, of course, has to recognise that all this will take a few years to be available in India. Currently, one cannot use STD for text transmission. Besides, overheads such as the cost of equipment at both ends will push the total cost of sending a letter higher than the bare communication cost described above. On the other hand, point-to-point links rented on an annual basis from the Posts and Telegraphs Department can carry a significantly lower rental than STD rates.)

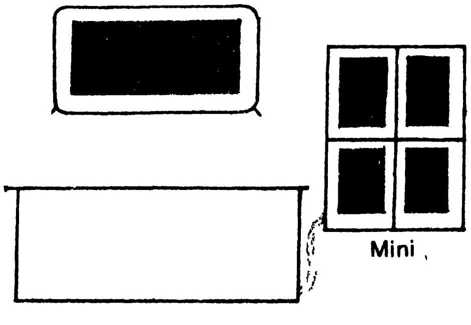
The magic of modems

There is a problem in sending messages over the telephone line. Computer signals, if sent directly over a telephone cable, get a hundred times weaker after they travel a few kilometres. The ever-present electrical noise gets mixed with the signal, and this is confused for the signal by the receiver. Cables also distort the original signals. How can one then use telephone circuits for sending data?

The answer is provided by MOdulator-cum-DEModulators (Modems). These devices convert computer signals to another form (also electrical) suitable for transmission through the telephone network. A simple type of modulator, for instance, sends a given frequency signal (2,200 cycles per second) to convey the symbol *0* and another frequency signal (1,200 cycles per second) to convey *1*. Signals varying in frequency do not lose their utility even when they are weakened a hundred times. Noise does not bother them too much. The demodulator at the receiving end will reconvert the received signals (varying frequency) to standard digital form used in computers (two levels of voltage).

The fact that a computer can store a message for some time in its memory and can deliver it later (at a more convenient time) leads to many possibilities. For instance, let us say you are trying to contact a telex machine a thousand kilometres away. The lines may be busy and you may not get a connection for 30 minutes. And when the lines are available, you may discover that the machine at the destination is busy sending messages to someone else, and you are again held up. If there is a store-forward unit (usually a computer) in the system, you can pass on your message with the right address to this unit as soon as it is free. The computer, which will be constantly watching line availability, will send off the message to the destination city as soon as the line is free. Another computer there can receive it even if the recipient's telex machine

A packet-switching system — Messages are cut into *packets* to be sent away. The first few packets are usually sent before the entire message has been typed in. The computers in the network choose an appropriate path from source to destination for each packet, taking into account congestion on each link on the way. Different packets of a message can take different routes and get reassembled in proper order at the end. *Minicomputers* handle communication functions, while larger *host computers* perform actual computation.



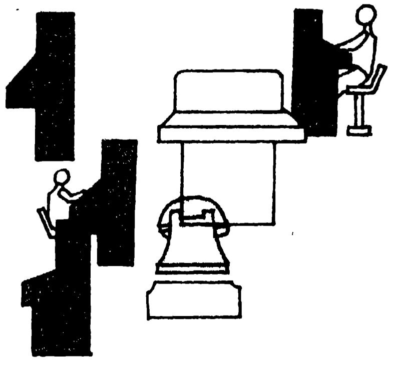
SCIENCE TODAY, MARCH 1980

(or similar terminal) is busy and give it to the machine as soon as it becomes free.

Thus the store-forward facility enables computers to handle communication lines very efficiently. Computers build up queues of messages which keep the lines busy throughout. Peak-hour traffic is stored up to keep lines occupied during lean periods such as lunch hours and midnight shifts.

Intelligent routing

Routing the messages efficiently is another important task. Imagine a computer network with a computer in each major city. Assume that each computer is connected to two or three neighbouring ones. How will a computer decide the route through which a message should be sent for delivery at the destination? It will use a *routing algorithm*, or a routing procedure, for this purpose. Taking into account the load on a line and the availability of lines (which lines are working and which are under maintenance), the algorithm will select the best route. Consequently, surprising routes may be chosen. For instance, a Bombay-Bangalore message may go through a route like this: Bombay-Nagpur-Hyderabad-Madras-Bangalore. Is this not wasteful? No. As long as communication links are paid for, it costs the same to keep them idle or busy. So one can very well use round-about routes involving less busy links to divert the load from an overworked direct link.



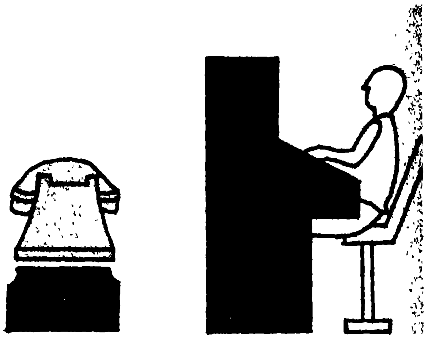
A hundred users can use one computer on a *time-sharing* basis

In computer networks, therefore, information on the availability and loading of different lines is monitored every second and shared with all the computers connected in the network. As a result, line failures need not hold up messages, which are immediately re-routed. And users need not know which paths their messages take. All they need to have is a guarantee of reliable transmission from the origin to the destination. How the computers route the messages in between is their own business and not that of the users.

Protocols

Computers handling communication tasks follow fixed patterns of behaviour in dealing with one another like police or army officers receiving their senior officials. These standardised patterns, called protocols, provide for dealing with a variety of contingencies. For instance, the work of carrying out a simple communication protocol can be specified like this: (i) if an expected message is received without transmission errors, send an acknowledgement, (ii) if a message (or a copy) you send is not acknowledged within a second, send a (new) copy, (iii) message $n+1$ can be sent only after you have received an acknowledgement for message n, and (iv) check every received message to see if it has any errors. Don't acknowledge messages with errors.

Carefully worked out communication protocols ensure that messages are not garbled en route and that all errors and problems created by deficiencies in transmission are properly handled. How can a computer detect a transmission error in a message received? This is done fairly easily by adding a little *redundant information*. For instance, suppose you have to read a long number like 61,394,572,891 over the phone to a friend. You can tell him to verify transmission by dividing this number by 7 and seeing if the remainder is 1. If there is any error in transmission, this check will fail (most of the time). Information about the remainder is redundant.



Modems change computer signals to make them suitable for transmission on telephone wires

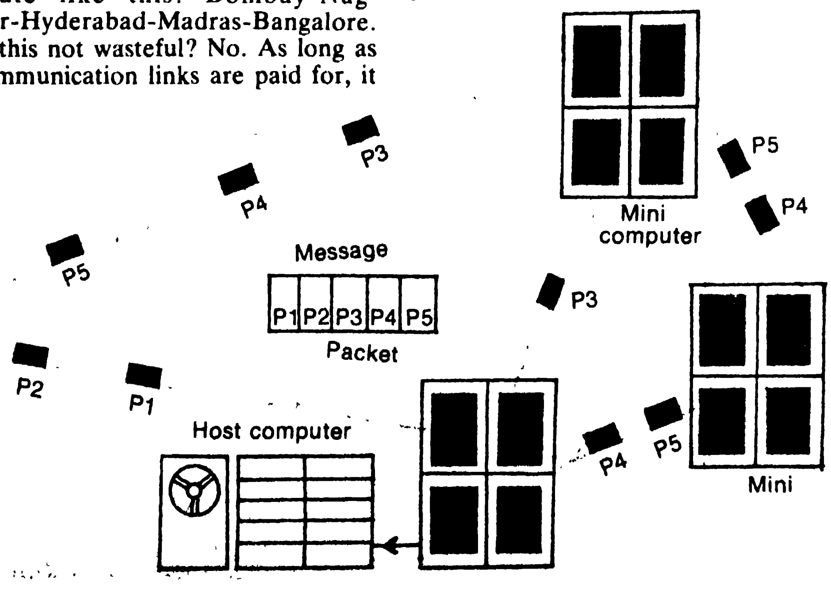
Compared to you and your friend, the computer is, of course, better equipped to divide numbers fast (and correctly). In computer networks, basically the same idea is implemented in a much more sophisticated way. Messages are treated as binary numbers and a form of polynomial division is used to find *remainders* which are sent as redundant information. If the message (or the remainder value transmitted!) is corrupted by noise en route, the check by polynomial division will fail at the receiving end. The message will be discarded as corrupted and the sender will have to send another copy from its memory.

Packet-switching

Invented hardly 15 years ago, the phrase packet-switching has become one of the key words of the computer era. The basic idea here is that long messages can be cut into smaller packets, properly numbered and sent through a computer-managed network, to be reassembled and delivered at the destination.

There is a basic difference between *packet-switching* and *circuit-switching*. Packets carry their destination addresses and are routed properly by computers managing the lines. For instance, one computer-to-computer link from Bombay to Pune can carry a few thousand packets for different addresses every minute.

The computer at Pune will "look" at the addresses and send them to their destinations. In contrast, when



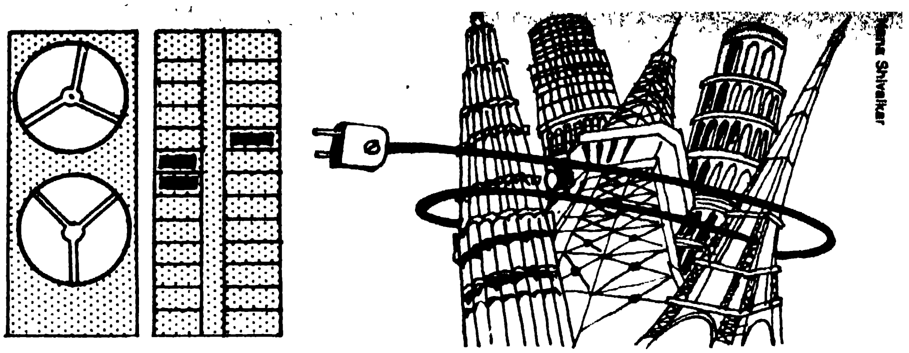
you telephone a friend in Pune, an electrical (or electronic) circuit is *reserved* for your use for the duration of the call (circuit-switching). Nothing else travels on this circuit at that time. If your friend hums and haws, the circuit capacity is just wasted. In packet-switching no circuit is reserved for anyone.

In a way, packet-switching is similar to the postal mail service. You drop your 'packet' with its address in the post-box and forget about it. The postal system will reach it to its destination. The postal analog of circuit-switching will be for you and your friend to set up a private mail system for this link—your own post-boxes, postmen, trucks and your own railway line.

Applications

The technology of data communication links computer users to their computers. A user can sit one km or a thousand km away from the computer he is using. As long as there is a telephone link between the two, work will go on.

This is particularly valuable with modern *time-sharing computers* which can be used simultaneously by dozens of users. These machines keep track of each user's job separately in their memories and respond to each user by giving out appropriate results. If the user group can be spread out geographically, they can use one computer to maintain common files. This leads to exciting possibilities. For instance, you cannot get a Delhi-Agra reservation in Bombay. The books are maintained in Delhi. You have to send a telegram and hope for the best. With data communication, a clerk in Bombay can consult a Delhi computer in a second, sell you the reservation and update the file in Delhi—all this without leaving his seat.


Shivalkar

Data communication and network technologies open up valuable possibilities for several industries, business and public services. Banks could clear cheques within hours instead of weeks. Railways and airlines can make it less painful for people to get reservations. They can also reduce wastage such as flying empty seats (information about which is not available to all sales offices in time). New forms of public services such as library information services can also be created using these technologies. Potential defence applications are quite significant.

But there may be a snag. If we are going to leave all kinds of valuable information in computer memories and make the computer accessible over the telephone line, how will one prevent misuse and fraud? How can one be sure that a crook will not find out someone else's bank balance and read someone else's medical record? How can the defence ministry prevent any telephone mechanic from tapping secret information?

These questions will be answered in a forthcoming issue.

Dr. Ramani is with the National Centre for Software Development and Computing Techniques, Bombay

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To pass an exam only

Textbook of Plant Physiology by C.P. Malik and A.K. Shrivastava, Kalyani Publishers, New Delhi, 1979, 533 pp, Rs 30

THE USE of the techniques of biochemistry and biophysics, in recent years, has increased substantially our understanding of plant physiology. As such, a sound knowledge of the fundamentals of these allied subjects is essential to understand more fully the various aspects of plant life. Nowadays, several new aspects like growth, development, dormancy and photophysiology are studied in addition to the classical ones. Since no single textbook covering all these topics was available to Indian students so far this book could be useful.

The authors have compiled information on most aspects of plant physiology and the principles of biochemistry and biophysics, making the various concepts clear using profuse charts. However, the chapterisation under various sections is not properly sequenced and balanced. There are several misplaced and overlapping accounts. The widely separated chapters on nucleic acid, nitrogen, and protein metabolism could have been condensed, to avoid repetitions as on pp. 7, 8, 282 and 297.

The chapters on carbohydrates, lipids and enzymes are too brief. A detailed description of electrophoresis should have gone in the appendix rather than in the account of enzymes. Modern concepts of free space, chemical potential and drought resistance should have been given in the chapters on water relations. The chapters on "Nutrition of plants" and "Catabolic processes" contain several accounts under vague headings ("ATP generation, p. 284, "Main features", p. 301) and imperfect diagrams. Physical aspects of the action of light on matter should also have been given. Talking of C-4 plants abruptly (p. 248) and use of the term "respiratory ratio" with respiratory quotient (p. 302 onwards) is confusing. The description and account of ATP formation on pp. 8, 245, 282 and 297 are misleading.

Inclusion of a chapter on works and workers of plant physiology in India is, however, creditable. But a very detailed account of the nature and functioning of the genetic material and the devoting of 26 out of 29 pages of the appendix (said to be on "practical plant physiology"), to reagents and techniques of advanced biochemistry cannot be justified.

The bold claims made by the authors in their preface, that the book aims at clearly stating and explaining the fundamentals, holds out a promise for the reader. One gets the feeling that they have failed in accomplishing it by employing expressions which are sometimes absurd and shake the very faith of the reader about his own fundamentals. Some examples:

p.12: "Protons are soluble... but not the electrons."

p.19: "Atomic weight of glucose..."

p.28: "In an inflated balloon, the confined gas has higher diffusion pressure than the surrounding air. Therefore when the balloon bursts, the gas would diffuse out."

p.221: "There is a loss" (in place of fusion) "of two molecules."

There are similar vague and confusing statements about genes being equated to a nucleic acid (p.1), energy bonds of ATP (p. 6), definition of adsorption (p.25), Emerson coming across a two pigment system (p. 229), migration of light quantum (p. 231), and calling Calvin's photosynthetic cycle, PMP pathway or HMP shunt (pp. 243, 244).

Misprints in the first edition of a book are not uncommon and this book is no exception. However, such slips as imperfect molecular structures, representing the isotope O^{18} as 180 (p. 217), and spelling mistakes in flow-charts (p. 107) cannot be excused.

The plates included in the book are, no doubt, good, but they have not been properly explained in the text. Many of these, printed only on one side of the art paper, seem to have contributed to raising the price of the book, in spite of the supply of paper at concessional rate. Although the book may be somewhat useful to some students who only want to pass an examination, (by reading just one book) ambitious students and serious teachers will find it rather disappointing.

D.N. MISRA RAJ

Dr. Raj is Professor and Head, Department of Botany, Government College, Khargone, M.P.

Useful indeed

Blueprint Reading—for Mechanical Traders by B.R. Sachdeva, Tata-McGraw Hill, New Delhi, 1979, 160 pp, Rs 12

THE EMPHASIS is on free-hand sketching, for which the book gives sufficient guidance in the basic construction of squares, circles, etc in Chapter 1. Such free-hand sketching can be useful to the mechanical trader because dimension sketches at the site could help him do scale drawings later.

The method described for constructing planar figures are so simple that with its help any person with sufficient language background and aptitude will easily be able to interpret any blueprint given to him. The two types of projections—first angle, third angle—are well-presented and self-explanatory. So are the construction of scales, types of bolt, nuts rivets and locking arrangements (topic 5).

With the help of topic 6, one can very easily distinguish between a permanent joint and a temporary joint. The description of coupled pipe joints in the type of valves used for fluids is well elaborated with the use of conventional signs.

On the whole, the book is packed with sufficient information to be useful not only to industry, but also to technical institutions like the Industrial Training Institutes and technical high schools.

S. PARAMASIVAM

Mr. Paramasivam is Maintenance Engineer at the Nehru Planetarium, Bombay

Awards and Appointments

INSA awards

DR B P PAL, Chairman of the National Committee on Environmental Planning and Co-ordination has been awarded the Indian National Science Academy's Aryabhata Medal for 1980 in recognition of "his scientific achievements of the highest order". Dr. Pal is a past president of the INSA

The Academy's Prof. T.R. Seshadri Birthday Commemoration Medal for 1979 has been awarded to Dr. S.C. Bhattacharya, Director, Bose Institute, Calcutta, for "his outstanding contributions in the field of nuclear products chemistry". The award consists of Rs. 1,500 in cash and a bronze medal.

The Academy's Srinivasa Ramanujam Medal for 1979 has been awarded to Prof. R.P. Bambah of Punjab University, Chandigarh, for "his outstanding contribution in the field of geometry and numbers".

Marconi award

Prof. Yash Pal. Director, Space Applications Centre, Ahmedabad, has been selected for the Marconi International Fellowship Award for 1980 in recognition of his contributions to "advances in communications science and technology for development".

Prof. Yash Pal is the first scientist from a developing country to win the Marconi fellowship, which carries a grant of US $ 25,000.

IC whistle-tuned remote control

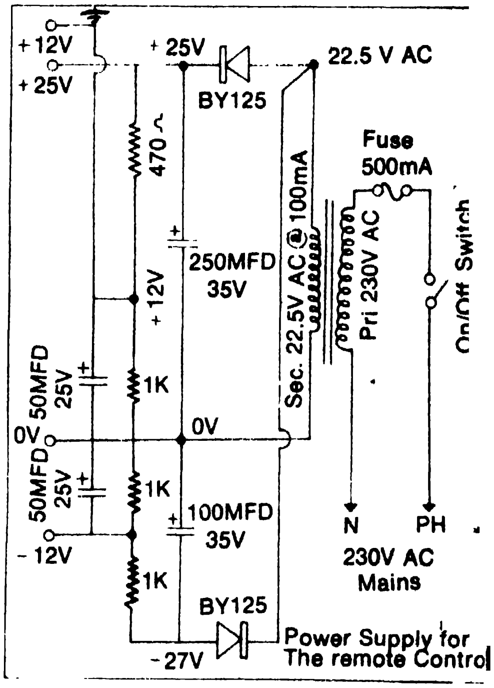
WITH this remote control you can, sitting comfortably on your sofa, switch on or switch off your TV, radio, tape recorder, record player or anything that works on electricity. One whistle will turn it on and it will remain "on" till another whistle turns it off. If you will study the electronic circuit diagram minutely, you will understand that the device described below is a combination of the "IC remote control for your TV or radio" (SCIENCE TODAY, March 1979) and "IC whistle-tuned switch" SCIENCE TODAY, February 1980, p.73)

The device basically consists of five stages using three commonly available integrated circuits and a few other components. The first stage of the whistle switch uses a loudspeaker as a microphone to convert the sound waves falling on it into corresponding electrical signals. These electrical signals are amplified by the integrated circuit pre-amplifier stage using IC 741C operational amplifier.

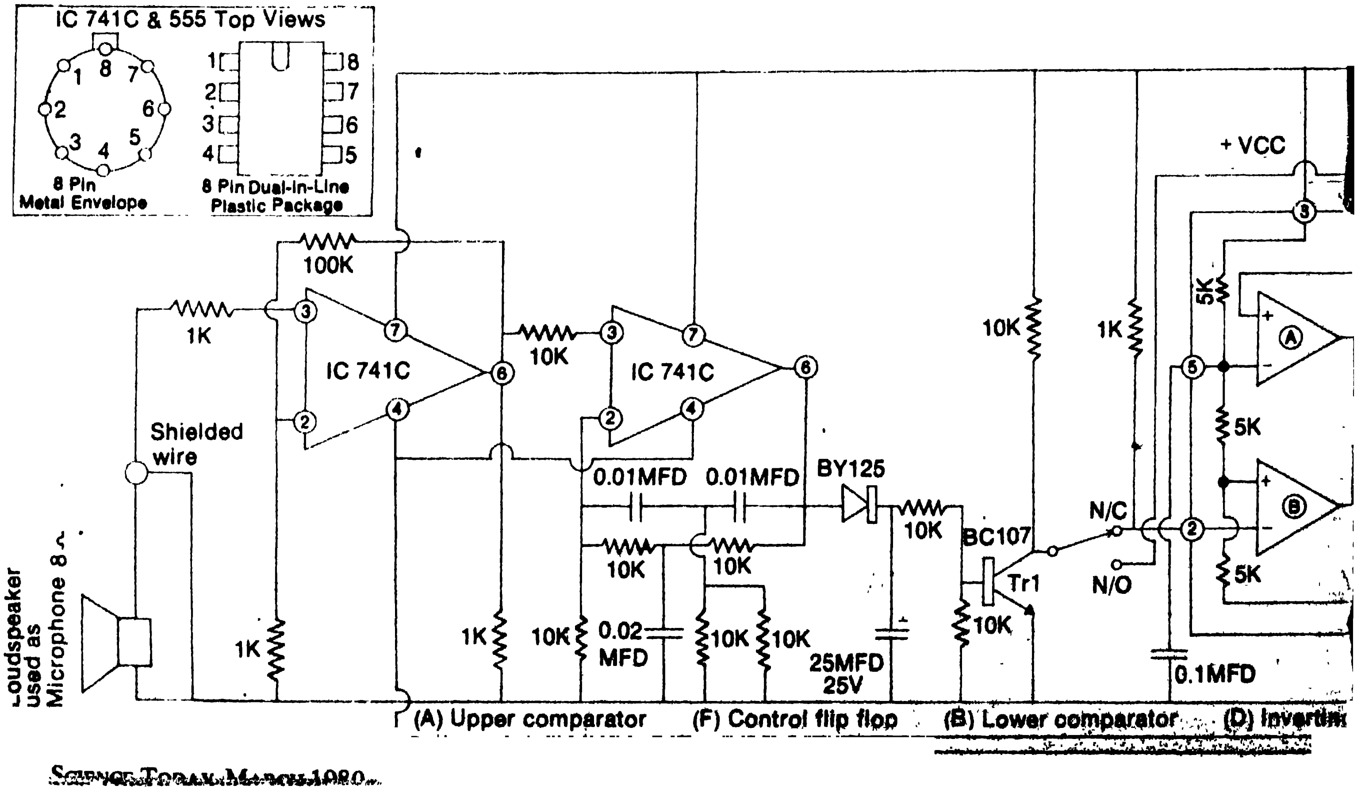
The second stage of the device also uses integrated circuit operational amplifier IC 741C. This stage has the twin-T network in its negative feedback. As the twin-T network is the bandstop frequency discriminative network, it provides virtually no feedback at bandstop frequencies and thus the operational amplifier provides very high gain at these frequencies. For all other higher and lower frequencies the network provides sufficient negative feedback and the amplifier is prevented from providing much amplification. As the normal whistle frequency is around 1.5. KHz, the resistors and capacitors in the twin-T network are so selected as to provide 1.5 KHz as the bandstop frequency. The amplifier stage thus discriminates between all other frequencies and amplifies only the frequency band around 1.5 KHz. The output provided by this stage is rectified and filtered to bring the transistor Tr1 into conduction.

The third stage uses IC 555 as a bistable multivibrator. As the name suggests, it has two stable states. The output provided by it can either remain low or high indefinitely till an external triggering pulse is fed to change it to the alternate state. To change the output from low to high state, the triggering pulse has to be fed to the trigger terminal No.2 of the IC Once triggered, the IC will continue to provide high output till an additional pulse is fed to its reset terminal No.4 to change the output back to the low state.

In the standby state of IC 555, that is, when no trigger pulse is applied to its trigger terminal No.2, the control flip-flop provides the high output which holds the discharging transistor in conducting state This clamps to ground the threshold terminal No.6, along with the common point of the external voltage divider connected to it. The flip-flop also drives the inverting amplifier to provide low output at terminal No.3 of the IC. The internal voltage divider 5K ohms resistors in series, provides 2/3 Vcc and 1/3 Vcc to the upper and lower comparators, respectively. These two voltage levels thus determine the threshold and trigger levels of the two comparators. Thus, when a negative-going trigger pulse, sufficient to make the trigger terminal No.2 less positive than 1/3 Vcc, is applied, then the lower comparator provides the output which changes the state of the control flip-flop from high to low. Thus, the control flip-flop cannot hold the discharging transistor in conduction and the inverting amplifier provides the high output at terminal No.3 of the IC. Though the threshold terminal and the common point of the 10K+10K voltage divider is now unclamped from the ground, the voltage divider determines the voltage level fed to the threshold terminal, which is approximately ½ Vcc. The threshold terminal in this type of circuit configuration will not be able to reset the flip-flop back to the normal high state, as the voltage provided by the voltage divider will always remain less than the 2/3 Vcc level required at the threshold ter-



Power Supply for The remote Control



minal. Thus, the output provided by the IC at its terminal No.3 will continue to remain in high state till a suitable pulse is fed at its reset terminal No.4. This will change the output provided by the IC at its terminal No.3 back to low state.

When the loudspeaker used as microphone receives sound waves, the first stage amplifies all the waves irrespective of their frequencies. The second amplifier stage, which has the twin-T network in its negative feedback stage, discriminates between the frequencies and only amplifies the band of frequencies around 1.5 KHz which happens to be the frequency of a whistle. The rectified output of this stage drives the transistor Tr1 in conduction. The whistle sound, thus, momentarily makes the transistor conductive and triggers the bi-stable multivibrator to change its state. It is extremely important for proper operation of the bi-stable multivibrator that when the relay is in unoperated condition, the collector of the transistor Tr1, should get connected, through the normally closed contact, to the trigger terminal No.2 of the IC. Similarly, when the relay is in energised condition, the collector should get connected through the normally open contact, to the reset terminal No.4 of the IC. This arrangement will automatically provide the pulse to the respective control terminal, either trigger or reset, suitable to change the stage of the IC to the alternate state, depending upon the existing state of the output provided by the IC at its terminal No.3.

The fourth stage consists of resistor-capacitor configuration and Darlington pair which drives the relay The resistor-capacitor configuration provides the necessary time delay of a second or two between bi-stable operation of the IC 555 and the operation of the relay. This delay is for avoiding continuous ON/OFF operation of the relay, called hunting, when the circuit becomes unable to select the proper stable state

The last stage, that is, the fifth stage of the device is the power supply. The positive and negative half-wave rectification from 22.5V AC transformer secondary provides 25V DC supply for driving the relay coil and 12V supply for the two IC 741 operational amplifiers and IC 555.

You will need :

Semiconductors : Integrated circuits : IC 741C - 2 Nos.; IC 555-1 No. Transistors : BC107-2 Nos.; SL100-1 No. Rectifiers : BY 125 or BY126-3 Nos.

Capacitors · Electrolytic : 250 mfd - 35V - 1 No.; 100 mfd-35V-1 No.; 100 mfd-25V 2 Nos.; 50 mfd-25V-2 Nos.; 25 mfd-25V-1 No. Polyester: 0.1 mfd - 1 No.; 0.02 mfd -1 No.; 0.01 mfd - 2 Nos.

Resistors (all ½ watt type) : 100 K-1 No.; 33K-2 Nos.; 10K-11 Nos.; 1K-10 Nos.; 470 ohms-1 No.; 47 ohms-1 No.

Loudspeaker 8 ohms permanent magnet, miniature type - 1 No.

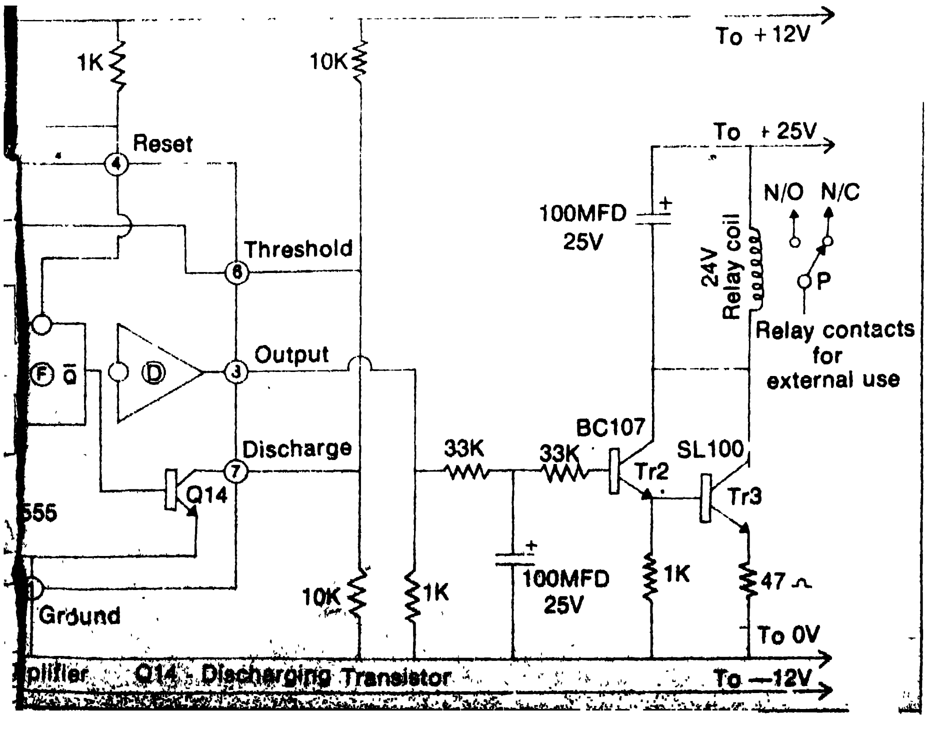
Approximate cost of the above electronic components in the Bombay market — Rs 100.

Relay · 24VDC coil, resistance more than 500 ohms, with at least two changeover contacts

Transformer . Primary, 230V AC. Secondary, 22.5V AC at 100 mA - 1 No

Misc ON/OFF switch, fuse holder with 500 mA fuse, connector strip, shielded wire, IC experimenter's vero board, solder, wires, screws and nut, suitable enclosure.

ANIL V. BORKAR



Form IV

(See Rule 8)

Statement about ownership and other particulars about newspaper entitled SCIENCE TODAY.

1. *Place of publication :* The Times of India Press, The Times of India Bldg, Dr Dadabhoy Naoroji Road, Bombay 400001.
2. *Periodicity of publication :* Monthly.
3. *Printer's name :* Tehemton Peshotan Pithavala for the Proprietors, Bennett, Coleman and Co, Ltd. *Whether citizen of India* · Yes. *Address :* 53 Rewa Apartments, Bhulabhai Desai Road, Bombay 400026.
4. *Publisher's name :* Tehemton Peshotan Pithavala for the Proprietors, Bennett, Coleman and Co, Ltd *Whether citizen of India :* Yes. *Address :* 53 Rewa Apartments, Bhulabhai Desai Road, Bombay 400026.
5. *Editor's name :* S K. Jha. *Whether citizen of India :* Yes. *Address* . 3A Somerset Place, Sophia College Road, Bombay 400026.
6. Shareholders

   Names and addresses of individuals who own the newspaper and partners or shareholders holding more than one per cent of the total paid-up capital as on 29 February 1980 *(1)* Ashok Kumar Jain, Shantiniketan, 12th Floor, 8 Camac Street, Calcutta 700017; *(2)* Ashoka Holdings Ltd, Times House, 4th Floor, 7 Bahadurshah Zagar Marg, New Delhi 110002; *(3)* Ashoka Viniyoga Ltd, 14 Govt Place East, Calcutta 700001; *(4)* Bharat Nidhi Ltd, Times House, 4th Floor, 7 Bahadurshah Zafar Marg, New Delhi 110002; *(5)* Nandita Jain, Shantiniketan, 12th Floor, 8 Camac Street, Calcutta 700017; *(6)* Manoj Kumar Jain, Shantiniketan, 12th Floor, 8 Camac Street, Calcutta 700017, *(7)* Akshaya Kumar Jain and Lakshmi Chandra Jain, c/o Bharatiya Jnanpith, B/45-47 Connaught Place, New Delhi 110001, *(8)* Nemi Chand Jain and Prabhudayal Dabriwala, c/o Sahu Jain Trust, 7 Bahadurshah Zafar Marg, New Delhi 110002; *(9)* PNB Finance Ltd, B/45-47 Connaught Place, New Delhi 110001; *(10)* Messrs Sahu Jain Ltd, Times House, 4th Floor, 7 Bahadurshah Zafar Marg, New Delhi 110002; *(11)* Messrs Sahu Properties Ltd, Room 21, Stephen House, 4 Dalhousie Square East, Calcutta 700001; *(12)* Sahu-Jain Charitable Society, Shantiniketan, 12th Floor, 8 Camac Street, Calcutta 700017

I, Tehemton Peshotan Pithavala, hereby declare that the particulars given above are true to the best of my knowledge and belief

(Sd) T P Pithavala
Publisher

Dated 1 March 1980

"If you order six, the doctor will give a fitness certificate"

The Bombay Mathematical Olympiad (Answers)

We give below the answers to the finals of the Mathematical Olympiad. The questions appeared in SCIENCE TODAY, February 1980. If you tried working out the questions, here is an opportunity for you to know how many you got right. The winners of the Bombay Mathematical Olympiad, all ninth and tenth standard students, averaged seven correct answers. Have a look. Maybe you'll have more interesting answers

1. It's clear that out of any three consecutive integers, one is divisible by 3 and out of any four consecutive integers, one is divisible by 4. Therefore, the product n of four consecutive integers is divisible by 3 and 4. We need only show that $\frac{n}{4}$ is even.

(*a*) If $n = (2m-1)2m(2m+1)\cdot(2m+2)$
$= 4m(m+1)(2m-1)\cdot(2m+1)$

Since $m(m+1)$ is even, we have $\frac{n}{4}$ is even.

(*b*) If $n = 2m(2m+1).(2m+2).(2m+3)$
$= 4m(m+1)(2m+1)(2m+3)$.

As in (*a*), $\frac{n}{4}$ is even.

2. If n leaves remainders 2, 3, 4, when divided by 3, 4, 5 respectively, $n+1$ will leave remainders 3, 4, 5, i.e. $(n+1)$ is divisible by 3, 4 and 5. Since 60 is the l.c.m. of 3, 4 and 5, we can take $n+1 = 60$ or $n = 59$. Note that n is not unique. However, it is the least with the required property.

(This problem is an example already considered by Brahmagupta and is originally due to the Chinese. A general case of this is known as the Chinese remainder theorem.)

3. We enumerate all the cubes from 1^3 to 12^3 as follows:

1, 8, 27, 64, 125, 216, 343, 512, 729, 1000, 1331, 1728. Since a, b, c, d are distinct, by trial and error, we find $a = 10$, $b = 9$, $c = 12$, $d = 1$.

(This was a problem considered by Ramanujan who found that this to be the least solution of the equation $a^3 + b^3 = c^3 + d^3$. If a, b, c, d are arbitrary positive integers, then there are infinitely many solutions).

4. By expanding $(n-1)^3$ and $(n+1)^3$, we have

$N = (n-1)^3 + n^3 + (n+1)^3$
$= 3n^3 - 3n(n-1) + 3n(n+1)$
$= 3n(n^2+2)$

If n itself is divisible by 3, then N is divisible by 9. If not, n leaves the remainder 1 or 2 when divided by 3. In any case n^2 leaves the remainder 1 and n^2+2 is therefore divisible by 3 Hence N is divisible by 9.

5. Using the hint, we see
$(m-1)(m+1)(n-1)(n+1) = (N^2-1)$.

From the second part of question, we guess that the left side could be a product of 4 consecutive integers. Setting $n = m+1$, we see the left side is $(m-1)m(m+1)(m+2) = N^2-1$. We have to find out N in terms of m so that this holds.

The left side is
$(m^2+m-2)(m^2+m)$
$= ((m^2+m-1)-1)\times$
$((m^2+m-1)+1)$
$= (N-1)(N+1)$
$= N^2-1$ if $N = m^2+m-1$.

For the second part, we need only observe if $N^2-1 = M^2$ for some M, $(N-M)(N+M) = 1$ which means $N-M = N+M$. i.e. $M = O$. i.e. $N = \pm 1$. Since $N > 1$, this is not possible. Hence the product of four consecutive integers cannot be a square.

6. Using the hint, we may suppose

$\log_2 6 = \frac{a}{b}$ $(b \neq o)$ ie. $2^{a/b} = 6$.

ie. $2^a = 6^b$
$= 2^b.3^b$

i.e. $2^{a-b} = 3^b$. Note that necessarily $a > b$, since $b \neq 0$.

The left side is even and right side is odd which is not possible. So we have a contradiction. i.e. $\log_2 6$ is not a rational number.

7. Let $n = p_1 \ldots\ldots p_k$ (p_i primes),
$\log_{10} n = \log p_1 + \ldots\ldots + \log p_k$
$\geqslant \log_{10}2 + \ldots\ldots + \log_{10}2$
(since $p_i \geqslant 2$) $\geqslant k \log_{10}2$.

8. From the definition of a polynomial, it is clear that for a polynomial f(x), the value f(1) is the sum of all its coefficients. For the polynomial $f(x) = (x-1)^3(x-2)^2(x-3)(x-4)$, $f(1)$ is 0.

9. Comparing the coefficients, we have

$a = \frac{k}{2}$, $b = l - \frac{k}{2}$ and $c = m$.

i.e. $k = 2a$, $l = a + b$ and $m = c$.

Obviously *k*, *l*, *m* are uniquely determined by a, b and c.

If Q(x) takes integer values for integral x, in particular $Q(-1)$; $Q(0)$ and $Q(1)$ are integers ; $Q(-1) = a - b + c$, $Q(0) = c$ and $Q(1) = a + b + c$ are all integers. From this we deduce that *k*, *l*, *m* are integers.

10. There are n pairs of consecutive integers in (1, 2, ... 2n).

Arranging the elements of S in increasing order

i.e. $S = (a_1 \ldots\ldots a_{n+1})$, $a_j > a_i$ if $j > i$, we observe that for at least one i, $a_{i+1} = a_i + 1$.

Otherwise $a_{n+1} - a_1$
$= (a_{n+1} - a_n) + \ldots\ldots + (a_2 - a_1)$
$\geqslant 2 + \ldots\ldots + 2 = 2n$
while $a_{n+1} - a_1 \leqslant 2n - 1$ since $a_1 \geqslant 1$ and $a_{n+1} \leqslant 2n$.

(This is a typical example of the so-called Dirichlet box principle which is often used in number theory. In its simplest form, it states if $n+1$ objects are put in n boxes, at least one box must contain at least 2 objects.)

11. It is enough to show that $s_i - i$ is even for some i. Suppose all $s_i - i$ are odd, then $\sum_{i=1}^{n} (s_i - i) \neq 0$, since there are an odd number of terms of odd numbers. But $\sum_{i=1}^{n} s_i = \sum_{i=1}^{n} i$ since (s_i) is only a rearrangement of $\{ i \}$.

i.e. $\sum_{i}^{n} (s_i - i) = 0$, and we have a contradiction.

12. Let S_1 and S_2 be the disjoint subsets. We need consider only two cases :

(*a*) S_1 has one element and S_2 has four elements

(*b*) S_1 has two elements and S_2 has three elements.

(The other two cases are obtained by interchanging S_1 and S_2).

In case (*a*), the five possibilities for S_2 are (2, 3, 4, 5), (1, 3, 4, 5), (1, 2, 4, 5), (1, 2, 3, 5), and (1, 2, 3, 4). The required pairs are given by (3, 5), (3, 4), (4, 5), (3, 5), (3, 4).

In case (*b*), the ten possibilities for S_2 are given by

(1, 2, 3), (1, 2, 4), (1, 3, 4), (2, 3, 4), (1, 4, 5), (2, 3, 5), (1, 2, 5), (2, 4, 5) and (1, 3, 5), (3, 4, 5).

The former eight have the required pair, namely (2, 3), (2, 4), (3, 4), (2, 4), (4, 5), (3, 5), (1, 2), (2, 4). The latter two do not have the required pair. However S_1 in these two cases is given by (2, 4) and (1, 2) which satisfy the required property.

(This is a very special case of the so-called van der Waerden theorem, which plays a central role in combinatorial mathematics.)

13. Let us enumerate all possible values for a_1, b_1, c_1, d_1,

(1) $a_1 = b_1 = c_1 = d_1 = 1$

(2) $a_1 = b_1 = c_1 = 1, d_1 = 0$;

(3) $a_1 = b_1 = 1, c_1 = d_1 = 0$.

(4) $a_1 = 1, b_1 = c_1 = d_1 = 0$.

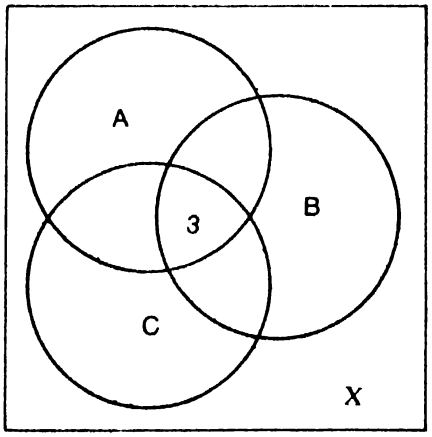
($a_1 = b_1 = c_1 = d_1 = 0$ is the trivial case.)

All the other possible values can be obtained by interchanging a_1, b_1, c_1, d_1 among themselves. Writing the a_2, b_2, c_2, d_2 below a_1, b_1, c_1, d_1 and a_3, b_3, c_3, d_3 below a_2, b_2, c_2, d_2 and so on, we have the following

(1)	(2)	(3)	(4)
1 1 1 1	1 1 1 0	1 1 0 0	1 0 0 0
0 0 0 0	0 0 1 1	0 1 0 1	1 0 0 1
	0 1 0 1	1 1 1 1	1 0 1 0
	1 1 1 1	0 0 0 0	1 1 1 1
	0 0 0 0		0 0 0 0

14. This is a simple consequence of a Venn diagram. If X is the set of all pupils, A, those who like mathematics, B Physics and C, Chemistry, we have to find out X − (A U B U C). Drawing the Venn diagram, using the data, we have the number of pupils in X = 30, A = 12, B = 14, C = 13, A∩B = 5 B∩C = 7, A∩C = 4.

A ∩ B ∩ C = 3;



The number of pupils in A U B U C is given by

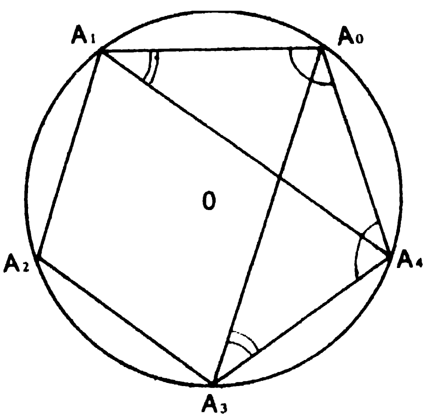
$= 12 + 14 + 13 - (5 - 3) - (7 - 3) - (4 - 3) - 2.3$
$= 39 - 2 - 4 - 1 - 6$
$= 26$

Hence X − AUBUC has 4 pupils.

15. Join A_0 and A_3, A_1 and A_4. Consider the triangles $A_0 A_1 A_4$ and $A_0 A_3 A_4$.

They are congruent because
$\angle A_1 A_0 A_4 = \angle A_3 A_4 A_0$
by hypothesis, and
$\angle A_0 A_1 A_4 = \angle A_0 A_3 A_4$,
since they are angles subtended by the same arc $A_0 A_4$ at two points A_1 and A_3. The side $A_0 A_4$ being common, the triangles are congruent.

Hence $A_0 A_1 = A_3 A_4$. By the same argument $A_0 A_1 = A_1 A_2 = A_2 A_3$. The statement is false for n = 4, for we can have a rectangle inscribed in a circle. However, if n is odd, the statement is true. The above argument for n = 5, holds for any *odd n*.



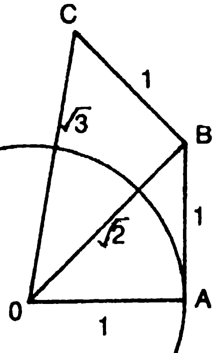
16. $A_0A_1 = 1$, $A_0A_2 = \sqrt{4 - 1} = \sqrt{3}$, $A_0A_3 = 2$, $A_0A_4 = A_0A_2 = \sqrt{3}$, $A_0 A_5 = 1$. Hence,

$A_0A_1 \times A_0A_2 \times A_0A_3 \times A_0A_4 \times A_0A_5 = 6$.

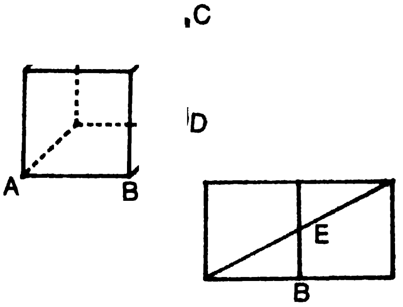
(The above statement can be generalised for any regular polygon of n sides inscribed in a unit circle, i.e. if $A_0 A_1 \ldots\ldots A_{n-1}$ is a regular polygon, then $A_0A_1 \times A_0A_2 \ldots\ldots \times A_0A_{n-1} = n$.

The proof uses the theory of complex numbers or trigonometry.)

17. Draw a unit circle with O as centre and if AB is a tangent at A and AB = 1 then OB = $\sqrt{2}$ by Pythagoras's theorem. For the circle with O as centre and OB as radius, if BC is a tangent at B and BC = 1, then OC = $\sqrt{3}$ by Pythagoras's theorem. This process can be repeated to obtain $\sqrt{m}$ for any positive integer m.



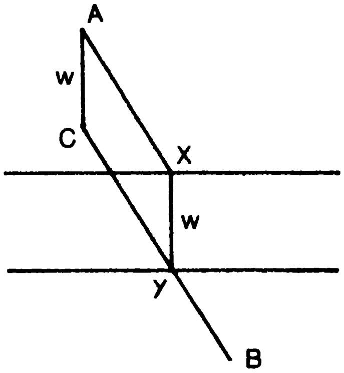
18. In the cube, let E be the midpoint of BD. Then the shortest path from A to C along the surface of the cube will be from A to E and then from E to C.



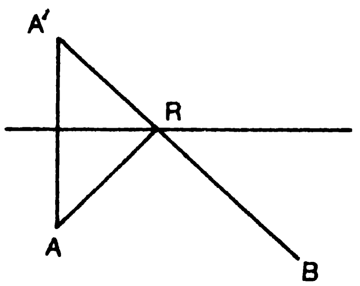
(This can be visualised by flattening out the side B D C. Then the shortest path from A to C is A E C, i.e., a diagonal.)

19. Let AC be perpendicular to the canal of width w. Join CB. If it meets the other bank at Y, the bridge XY is the required position, i.e. the traveller goes from A to X, crosses the canal at X and goes from Y to B.

(This can be imagined by taking w to be zero so that AB is the shortest path and gradually increasing w.)



20. This problem uses the principle that light takes the shortest route. Imagine L as a mirror. Then if A′ is the reflection of A in L, join A′ and B. If it meets L at R, then AR + RB is a minimum as R moves along L.



(Note that AR = A′R so that AR + RB minimum is the same as A′R + RB is minimum and this is obvious if A′, R and B are in the same line.)

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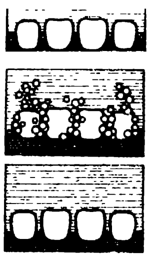

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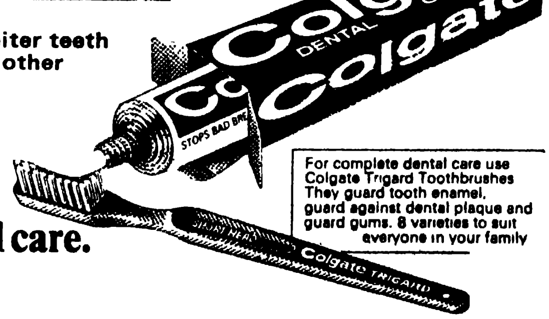

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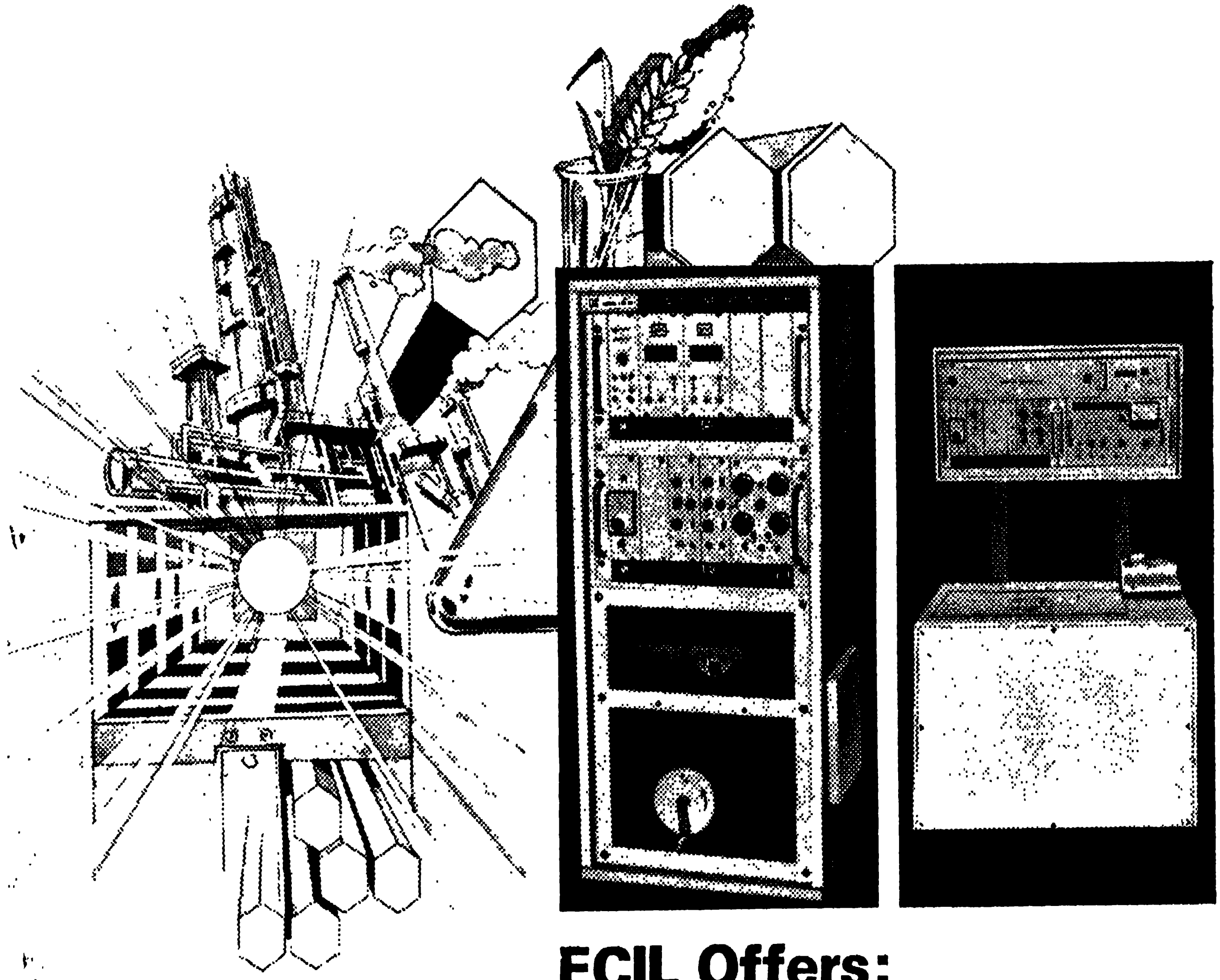

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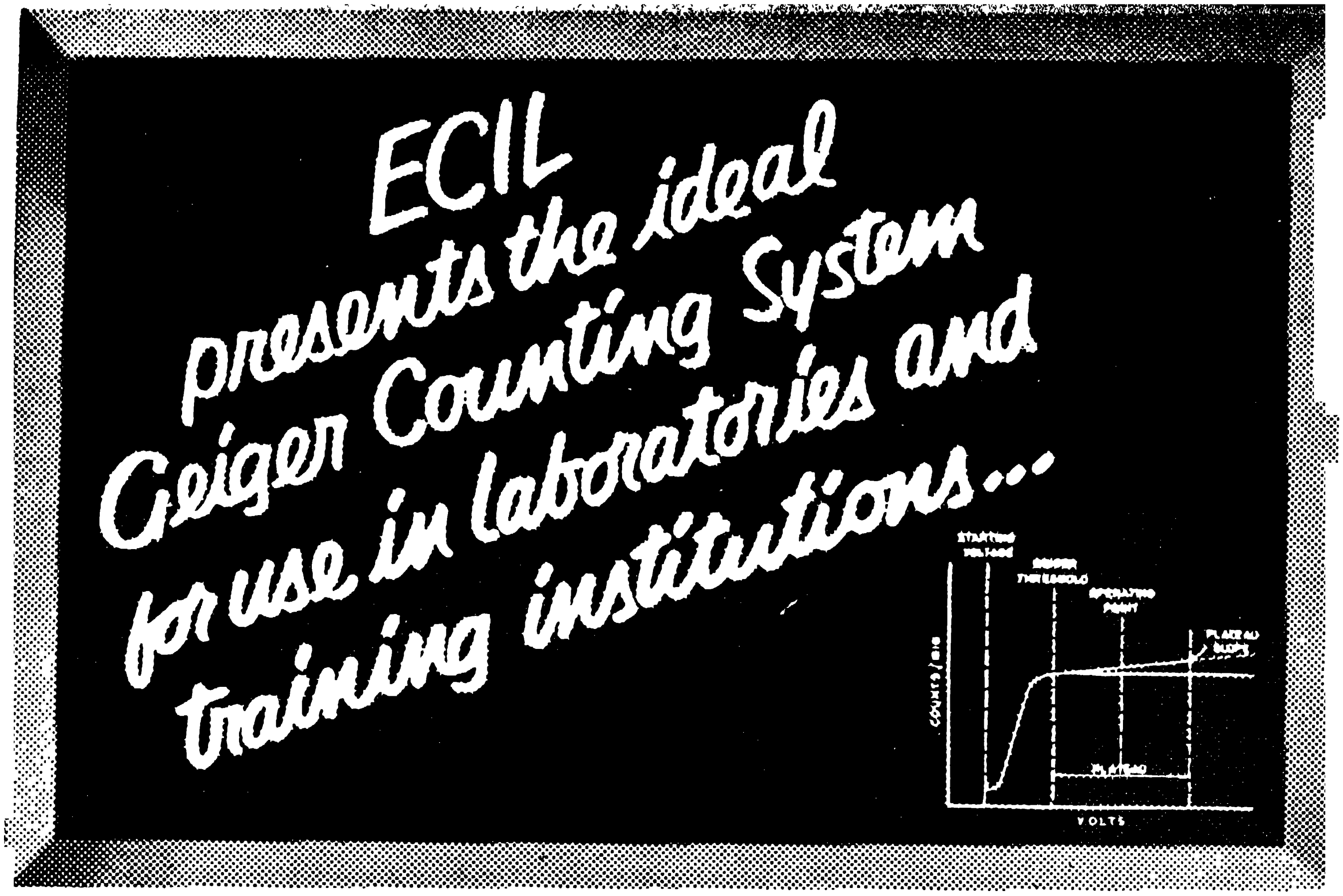

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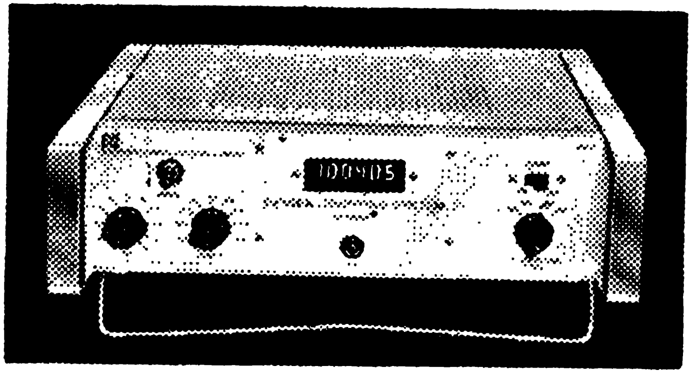

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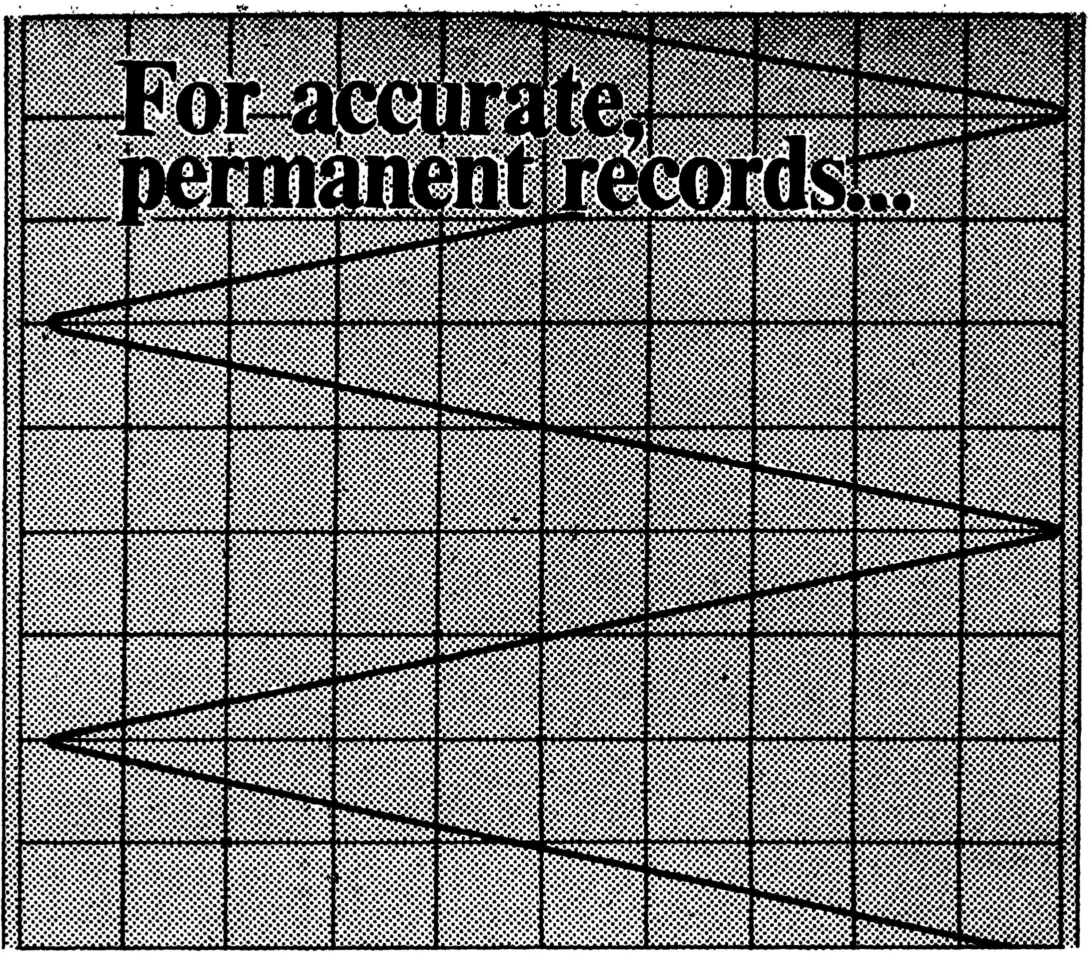
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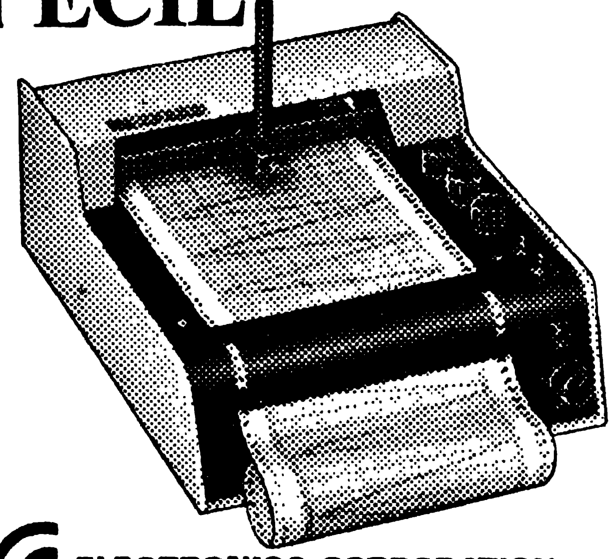

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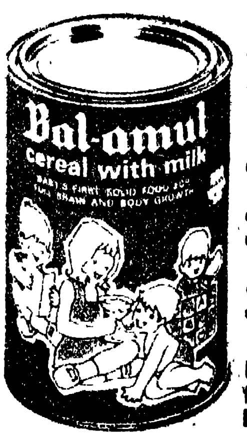

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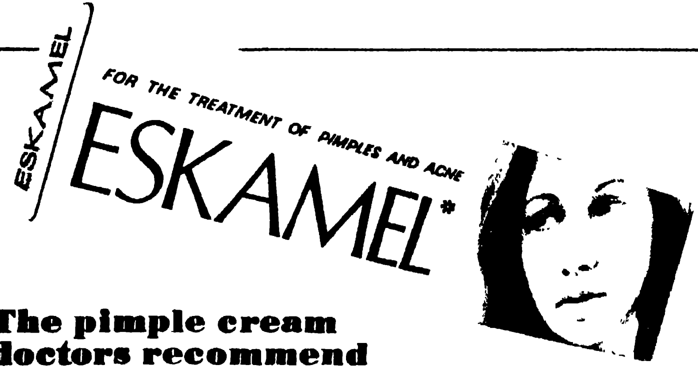

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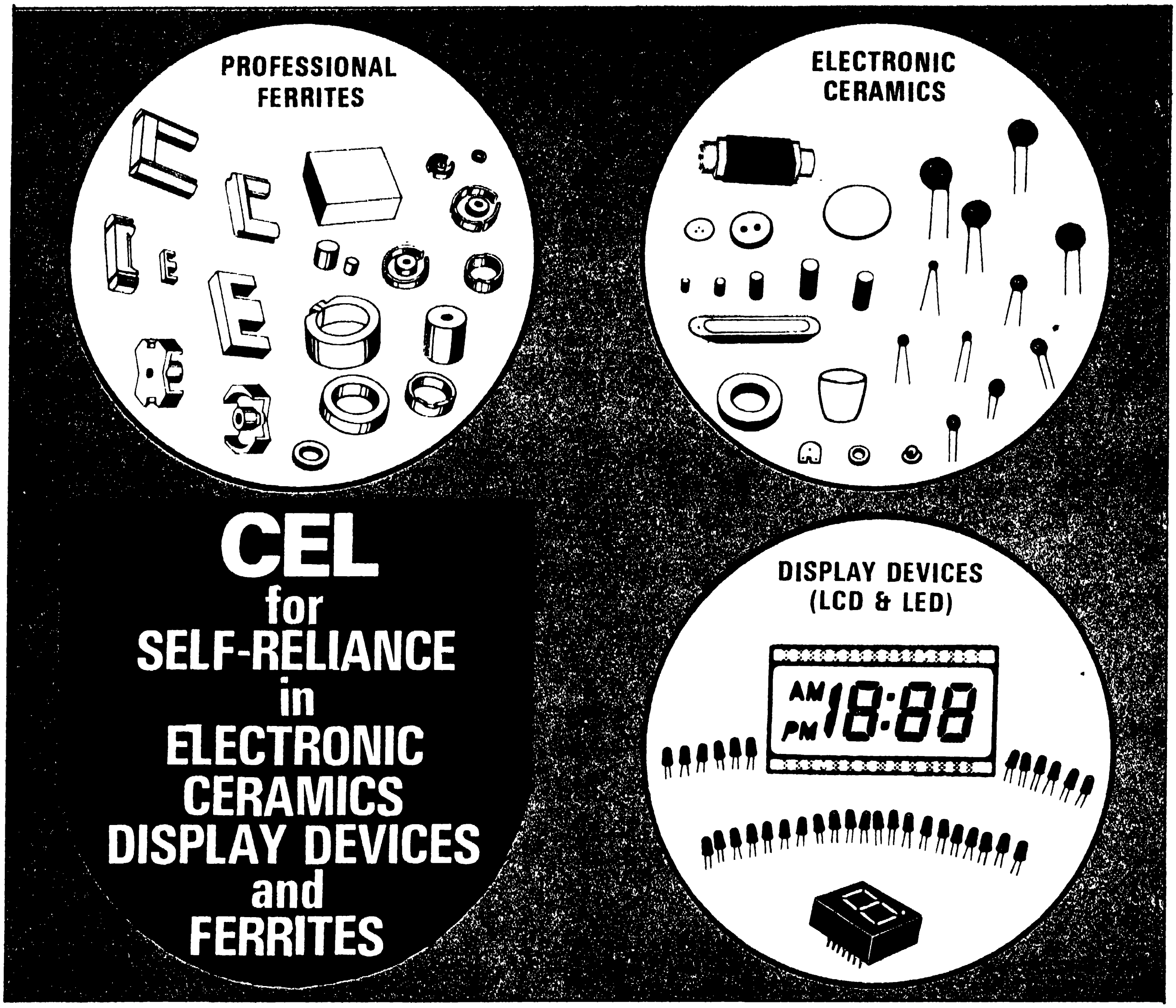
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Science Today

April 1980 Vol 14 No 4

17 **Helium probe for the earth's secrets**
S K. Gupta and P. Sharma
The measurement of the way helium is distributed on the earth is providing us with a new picture of our planet's history

61 **Design of indicators**
Krish Pennathur
Whether weight - watching or satellite - launching, what would be the best shape, size, colour or sound of the dials, blinking lights and pointers?

68 **The question of motive**
Pritam Phatnani
In the absence of other clues, the 'Why' of the crime can often point to the criminal

72 **The method of science—4**
How to use the method of science to frame answers to our questions

26-49 Low-cost housing

An additional 175 million people will be living in Indian cities in 2001, apart from the 221 million more in the villages. A large proportion of the additional population is unlikely to have a decent roof over their heads—unless we plan right now to provide for them...Resources are limited, so are the choices before planners. A 24-page special feature

26 **Technology or action?**

28 **Housing the urban poor**
P.M. Apte

30 **Bombay: the narrowing options**
V.K. Phatak

34 **A low-cost technology**
Dinesh Mohan

40 **Sites and services**
Shirish Patel

Case studies and alternatives

42 **Calcutta's bustee improvement programme**
Dilip K. Roy and Jai Sen

44 **Delhi squatters resettlement project**
S K. Das

45 **Choice—an alternative approach**
Jai Sen

48 **Indigenous technology in Kerala**

7 Letters
8 Viewpoints
11 View from New Delhi
12 Blurs and Bright Spots
13 Science Shapes Life
23 Round-up of Research
25 This World of Science!
25 . . and of Scientists
51 Ideas & Inventions
53 Books
55 Another Window
57 If...
63 Fun with Mathematics
65 Quiz
71 Tell Us...
75 You Too Can Do It
77 Brain Teasers

8 Brain-drain—do we need more scientists or more science?

11 Electronics—watch the pitfalls

12 Banking on brilliance

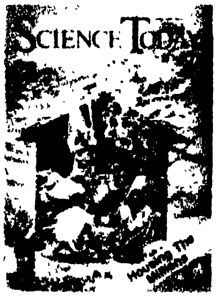
55 Young scientists define their roles

57 If the earth lost its protective ozone screen

65 How much do you know about tobacco smoking?

71 Why are some people obese?

75 Smoke alarm



Cover:
Photos: S.N. Kulkarni
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Editor:
Surendr Jha

Single copy: Rs. 2
Subscription: 1 year Rs. 20;
2 years: Rs. 39; 3 years: Rs. 58.

Editorial queries are to be addressed to the Editor, SCIENCE TODAY, Times of India Building, Dr. D.N. Road, Bombay 400001. Unsolicited articles must carry adequate return postage.

Subscription queries and payments should be addressed to the Circulation Manager, SCIENCE TODAY, Times of India Building, Dr. D.N. Road, Bombay 400001.

Printed and published for the proprietors, Bennett, Coleman & Co., Ltd., by T.P. Pithavala at Usha Offset Printers Pvt. Ltd., 125, Govt. Industrial Estate, Kandivli, Bombay 400 067. General Manager: Dr. Ram S. Tarneja. Branches: 7, Bahadurshah Zafar Marg, New Delhi 110 002; 139, Ashram Road, Ahmedabad 380 009; 105/7A, S.N. Banerjee Road, Calcutta 700 014. Offices at 13/1, Government Place East, Calcutta 700 069; 63, Montieth Road, Egmore, Madras 600 008; 407-1, Tirath Bhavan, Quarter-gate, Pune 411 002; 26, Station Approach, Sudbury, Wembley, Middlesex, London, U.K. London Tel. 01-903-9696

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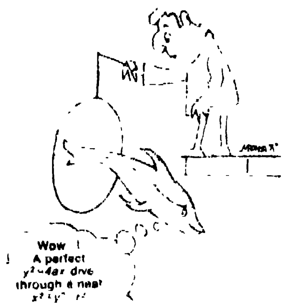
IF DOLPHINS ARE INTELLIGENT

B.F. CHHAPGAR'S observations on the intelligence of dolphins (SCIENCE TODAY, January 1980) made diligent reading. In this connection, I would like to quote Dr. H.L. Mathews, FRS He says, "If as claimed, they (the dolphins) are extraordinarily intelligent, why do they docilely submit to being forced to swim round and round in a tank and perform tricks, apparently with enjoyment, before hordes of gaping bipeds, instead of splashing about at liberty in the ocean? One would expect a sensitive, intelligent creature would be more likely to pine and die." (*The Life of Mammals*, 1971, 2, 224.)



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EDUCATION: WHY BLAME A CLASS?

IN "Wanted: A New Educational Policy" (Viewpoints, November 1979) Prof. J.P. Naik at the outset says that the character of the existing system of education is class-oriented. Further, he says it is a system created and maintained by the upper and middle classes, essentially for their own benefit.

The author wants a peaceful and non-violent movement to be launched among the upper and middle classes to enable them to see the writing on the wall and to accept essential curbs on their consumption of education (as of other goods and services). Are the middle and upper classes to withdraw their children from schools and colleges to a desired level on a basis to be fixed by social and educational reformers?

Prof. Naik must spell out his theory in clear terms before blaming particular classes of people for our country's tardy progress. The progress or utility of education depends entirely upon the individual seeking to learn and upon the will, talent and intelligence latent in the individual. It does not depend on the class or income group to which he or she may belong.

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WRONG VITAL STATISTICS'

IN THE box on p.40 (SCIENCE TODAY, February 1980) entitled "The Sun: Vital Statistics" you give the distance of the sun from earth as 1.496 million km. This is wrong, and should read as 149.6 million km. Since many readers rely on SCIENCE TODAY as a direct source of information, you should correct this error.

Rajiv Sood
36, Hostel A,
TIET, Patiala

Mr. Sood is right. The decimal point was misplaced.—Ed.

NOT THE SAME SILKWORM

"RAISING Silkworms on Tapioca" (Science Shapes Life, December 1979) gives the misleading information that silkworms generally raised on mulberry leaves have been successfully reared on tapioca leaves in Kerala.

The mulberry silkworm (*Bombyx mori*) is different from the Erisilkworm (*Philosamia ricini*). The two belong to separate families Bombycidae and Saturniidae, respectively. While the former is reared on mulberry alone, the latter, generally reared on castor, can be reared on some other host plants also. Tapioca is one of them.

Here, at Jodhpur, work on the Erisilkworm has been going on for the past four years, investigating the differential effects of feeding the worms on tapioca and castor.

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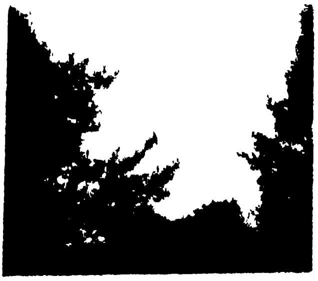
RARE SIGHT

A BRIGHT star was observed very close to the moon on the night of 20 January 1980. A day later, the star was not in the same place. Since this seemed rare and interesting, could I have an explanation?

L.R.K. Reddy
ANC/4, A Camp
Kurnool 518 002 A.P.

The shining object very close to the moon is the planet Venus which is the brightest object in the sky at night after the moon. The paths of the planets lie in a narrow belt in the sky called the zodiac. The moon appears to rise and set as the other heavenly bodies do because of the motion of the earth. But, in addition, there is also an 'eastward' motion of the moon along the 12 constellations of the zodiac. Its rate is about 13° per day. During its journey across the sky once in nearly 27½ days it appears close to every planet except Pluto. If it appears very close, then the planet is said to be in conjunction with the moon.



Courtesy: Astronomy

This time lapse photograph of the moon (exposure 4 seconds, f/8 at 8 min intervals) shows a conjunction of Venus and moon similar to the one observed by Mr. Reddy. The comparison of the earliest (upper left) and the last (lower right) positions clearly reveals the eastward motion of the moon. —Ed.

OFFSPRING IN PARTHENOGENESIS

THE ITEM, "Fatherless Offspring" (Science Shapes Life, January 1980) states that the offspring resulting from parthenogenesis is always female. This is not true.

In the honeybee, unfertilised eggs produce the (male) drones. The workers (female) come only from fertilised eggs. Parthenogenesis may result only in males as with honeybees, or only in females as with some insects, and sometimes both as with gall-wasps and moths.

B.S. Warrier
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NEED FOR ADULT EDUCATION

PART OF the success of the People's Science Movement in Kerala (SCIENCE TODAY, January 1980) is due to the co-operation of the Keralites who enjoy a comparatively high literacy rate. Evidently, it is only through adult education that we can orient the minds of people towards a rational and scientific approach to life.

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LAXMAN'S CARTOON

R.K. LAXMAN'S cartoon captioned "The municipal water supply became so bad, I thought of an easier way" (This World of Science! January 1980) was interesting. But Mr. Laxman should have doubled the size of the hydrogen tank in order to conform to the formula, H_2O.

C.G. Balaj
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Secunderabad 500 361

Brain drain—do we need more scientists or more science?

THE phenomenon of 'brain drain' has been widely commented on in the press of this country as well as in international forums. Our politicians and the public have frequently appealed to the patriotism of our scientists abroad and exhorted them to return and work in India. The public protest against 'brain drain' has, in fact, become more incessant in the past two decades. But our science managers, who must at least share part of the responsibility for this phenomenon, have normally ignored it; apart from a few stray remarks, they have said little publicly on this problem. As to the working scientists who should be best informed on the subject, their silence has been more or less total. It may be partly due to their own apathy, but largely it is due to the conduct rules which deny them the right to express their views publicly.

Now that the entire Indian scientific scene is in a state of crisis, it is high time that working scientists came out of their shells and joined in the public debate on matters concerning science policy and management in this country. Dr. Raja Ramanna's recent interview to the UNI (1 March 1980) provides a good starter for such a debate on the specific problem of 'brain drain' and the more recent phenomenon of internal brain drain, that is, the flight of brighter students to non-science courses in universities. While expressing some of our thoughts on these problems, we earnestly hope that the government will not use the outdated conduct rules to suppress this therapeutic debate which requires participation by individual working scientists.

In his interview, Dr. Ramanna has warned that there may be "a serious shortage of scientists in the country in about 15 years unless the rush of talent towards subjects other than science is checked". He has also decried "the tendency on the part of industry to import technical knowhow at the cost of Indian scientists". According to Dr. Ramanna, a large number of students as well as their parents "prefer banking and commerce as there were not enough openings for science graduates". To reverse this trend, he has pleaded for a change in the present policy of liberal import of technical knowhow.

These views, coming from someone who has been associated with the management of Indian science for so long, deserve serious attention of all those interested in the future of the country. In particular, Indian scientists must ask themselves why they can no longer attract the best students to their profession. Is it merely because our industry, ignoring local R and D effort, prefers to import knowhow that could be developed here? If so, why does it import foreign knowhow at the cost of local R and D? What has been the record of government organisations in this regard? Alternatively, could the present preference of brighter students for banking and commerce courses be attributed to the experiences of those who had earlier chosen careers in science? In fact, we must also inquire whether it is advisable for us to go on recruiting new students to science courses at an undiminished rate even if we are not sufficiently well organised to make optimum use of those who are already in science. Although we boast of possessing the world's third largest scientific community, our rate of industrial expansion remains one of the lowest in the world and the problem of mass poverty is constantly increasing. By further increasing the number of scientists we may acquire the second, even the first, place, but it is unlikely that this by itself will solve many of our problems. *What we need is more science and not merely more scientists or richer scientists.* To do more science, we must first organise things so as to make best use of those who are already trained in science. Have we done that?

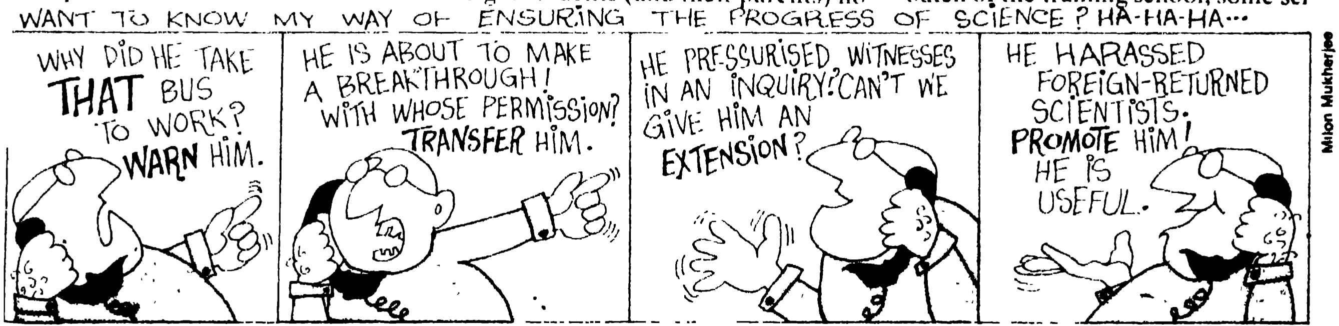
Seen in this light, it is surprising that while lamenting the loss to Indian science of those who have chosen banking and commerce as their careers, Dr. Ramanna seems quite indifferent to the loss of those of our brighter students who have chosen science as their career but either cannot find suitable jobs in this country or have to remain scientifically unproductive due to the inhospitable conditions prevailing in our scientific organisations. In his opinion, "the problem is not brain drain but drain brain"! Like most other managers of Indian science, Dr. Ramanna seems to be hostile towards those Indian scientists who want to return home and work here. "They", he says, "should not expect foreign situation at home" (as if many do) and adds that "they should be prepared to fit into things here". The question naturally arises whether "things here" are really so good that changing them is unthinkable merely to make use of our better-trained scientists! If we can consider changing our import policy to attract better students into science, then why cannot we consider improving "things here" to encourage those Indian scientists abroad who have learnt sophisticated technologies relevant to our needs to work in this country and develop those technologies here? This would make us more self-reliant and reduce the need for direct import of technology. Why are our science managers so averse to doing anything in this regard? Indeed, what could we gain by turning the brighter students from banking and commerce to science if we do not care whether they eventually work here or abroad? Are we worried about shortage of scientists in other countries?

To make best use of the available talents and potential, if the leaders of our scientific community are not prepared to change "things" that are within their control, then their concern for the future of our R and D and their demand for change of policies that affect the interests of others are bound to remain unconvincing and even suspect. They might even be interpreted as diversionary tactics aimed at taking public attention away from their own responsibilities. Though we fully subscribe to technological self-reliance, we feel it is unfair to ask our industrialists to forego their capitalistic prerogative in order to improve our R and D, and this when we ourselves are not prepared to change "things here" to achieve the same objective.

It is true that a certain fraction of Indian scientists prefer to settle abroad for better emoluments and better research facilities. At times, they may also acquire research interests of no relevance to this country. Obviously, nothing can be or need be done to bring those scientists back. However, there is a large number of scientists who are willing to return if given a reasonable opportunity to work in this country. None of the latter category is so unrealistic as to expect "foreign situation" at home, in respect of emoluments or research facilities. *Only, because of their higher competence and training in a freer scientific environment they tend to be less submissive and do expect more freedom and dignity than is normally accorded to scientists in this country.* Unfortunately, the insecure Indian science managers, who have systematically created a culture of fear in our laboratories, see in them a threat to their own power and to their reputation as great scientists. They vehemently discourage their return home. In the few cases where foreign-trained scientists are absorbed, they are treated unfairly and subtle pressures are created to compel them to go back. And yet, ironically, most of the managers owe their own "exalted" positions mainly to foreign degrees obtained a few years earlier.

To say that "the problem is not brain drain but drain brain" may be a smart pun but it is not good logic. The fact is that the two are different symptoms of a common disease. The only difference is that the brain drain, that is the flight of better Indian scientists from Indian laboratories, started much earlier than the flight of talented students from science courses. The reason is obvious. Those who are now running away from science have been made wiser by the experience of the earlier scientists.

A close look at the happenings in almost any one of our research institutes would illustrate the point. The decreasing attractiveness of scientific careers can be largely traced to the mismanagement of our science by people to whom their personal power and privileges were far more important than any genuine interest in our science or scientists. Let us take the example of the Bhabha Atomic Research Centre (BARC) in Bombay which is the biggest and among the most prestigious R and D institutes in the country.


WANT TO KNOW MY WAY OF ENSURING THE PROGRESS OF SCIENCE ? HA-HA-HA···
WHY DID HE TAKE THAT BUS TO WORK? WARN HIM.
HE IS ABOUT TO MAKE A BREAKTHROUGH! WITH WHOSE PERMISSION? TRANSFER HIM.
HE PRESSURISED WITNESSES IN AN INQUIRY? CAN'T WE GIVE HIM AN EXTENSION?
HE HARASSED FOREIGN-RETURNED SCIENTISTS. PROMOTE HIM! HE IS USEFUL.

Milon Mukherjee

Right from its inception in 1954, BARC has been the main R and D wing of the Department of Atomic Energy (DAE). Its objective has been to work for complete self-sufficiency in nuclear technology. Since this technology was to be used almost exclusively by the different units of DAE, for most part there was no question of the know-how developed at BARC going unused due to such reasons as industry preferring the imported know-how. (Radioisotopes, which had non-DAE users, enjoyed statutory protection in that no radiochemicals available with BARC could be imported by anyone in India.) The R and D opportunities for BARC scientists, therefore, could be limited only by the requirements of the Department which had ambitious long-range plans to make heavy water, enrich uranium, produce reactor fuels, recycle spent fuels, design and fabricate first generation nuclear reactors, develop breeder technology and sophisticated facilities for nuclear research, apply isotopes to biology, agriculture and medicine, and much more. Nor were there any theoretical constraints against raising the salaries and the status of the scientists fast enough. The promotion policy permitted upgrading of scientists as and when considered necessary without waiting for new vacancies etc. In principle, BARC scientists could have been promoted faster than their counterparts elsewhere in the government, including the Indian Administrative Service.

Training programme

To meet the growing needs of the atomic energy programme, the BARC Training School was started in 1957. In its early years, this training school provided one of the most attractive channels to young science and engineering graduates to enter a scientific career and it attracted a large number of the brightest students. Today, things have changed dramatically. Last year 30 physics trainees were required, but, despite sending repeated reminders, hardly 10 good candidates could be found. Why do bright students (and their parents) no longer find a career in BARC sufficiently attractive? It is not possible to explain it away in terms of our industry's preference for imported technology. For actual reasons, one must look at what has happened at BARC during the intervening years.

To many trainees, it was clear within their first few years at BARC that it did not provide a sufficiently stimulating work situation or fair opportunities for career advancement. (We must clarify here that career advancement to most scientists does not mean only an increase in their take-home pay. Though an analysis shows that over the past two decades the real wages of even those scientists who received their promotions regularly have increased by hardly 2 per cent, BARC scientists have not demanded increased salaries. The most frequent grievances of the scientists have concerned lack of opportunities for work and professional advancement.)

To the more perceptive among them, it was also clear that the management, especially after Dr. Bhabha's untimely death in 1966, was interested neither in genuinely building up healthy scientific traditions nor in making a concerted or honest effort towards achieving the objectives of the atomic energy programme. Those near the top were far more interested, instead, in empire-building, power-grabbing and internecine quarrels. They had little time to look after the problems or the morale of the working scientists. For a working scientist to feel secure or wanted, good performance or commitment to the department's programmes were not enough. Proper antecedents and personal loyalties to those in power were far more important. Academic freedom was non-existent. Working scientists had no say in decision-making.. Fear was all prevalent. Promotion norms were kept confidential and varied arbitrarily. Career planning was impossible. No known policies governed project assignments, seniority, confirmation, promotion, housing, deputations, anything. The scope for manoeuvring things for or against an individual scientist was unlimited. From the same batch of the training school, some scientists could be promoted after three years and others after 10 or 15 years—*and no questions asked. No one bothered about equity, fairplay, the rights of the working scientists or the targets of their projects. There was no 'rule of law'.* In fact, there was little scope for doing work with dignity. All this was hidden from the people by a powerful and cleverly operated public relations machinery. This was the state of things into which everyone was expected to fit. Many could avoid complete humiliation and frustration only by migrating abroad. Those who remained constantly grumbled and frequently took mental flight to godmen or psychiatrists.

A large number of bright Indian scientists who had returned from abroad to work in this country and had accepted relatively modest positions at BARC later left. Most of them were unhappy to have to return abroad. The commonest reason for their decision to leave was the discriminatory treatment meted out to them compared to those who had not been trained abroad or were eager "to fit themselves into things here". As an unpublicised rule, the period spent abroad by these scientists was normally subtracted from their total professional experience while fixing their pay scales and salaries. In several cases, this meant a foreign-trained scientist being graded up to five years junior to his erstwhile classmates who had not been trained abroad. Those who could escape such humiliations or were determined to stay back often had to make so many compromises in the process of "fitting into things" here that they lost most of their enthusiasm, vigour and commitment. Often they became a burden on others because they had to maintain a past reputation without being able to put in sustained work. They resorted to claiming credit for the work of junior colleagues and thus alienated them. Others who maintained their integrity were mostly ignored by the management and eventually declared unproductive or unprogressive.

All this should have been a sufficiently strong indication to any honest manager that something was seriously wrong with the set-up at BARC and that things needed to be rectified in the long-term interest of the atomic energy programme and Indian science. It could have also been foreseen that if even one of the best scientific institutions in the country could not provide sufficiently satisfying jobs to the brighter scientists and forced them to leave the country, it was bound to disenchant good science students and eventually lead them to turn away from science courses.

Unfortunately, science managers at BARC were not prepared even to admit that there was something wrong, let alone correct it. No efforts were made to understand the actual reasons why the bright scientists left, and to persuade them to stay back. The only attempt to keep scientists from leaving was in the form of one-sided bonds which made them feel captive or the use of conduct rules which barred them from even corresponding for outside jobs or fellowships. The earlier facilities for study leave for higher training abroad were progressively withdrawn, forcing more and more of the bright scientists to resign. To add to the humiliation, a resigning scientist was often required to serve the entire notice period of one or three months before being relieved. This was not to find replacement for him but purely to upset his future plans. The hostility of the authorities towards a resigning scientist was felt so intensely by the latter that he often refrained from disclosing his future plans even to his close colleagues, lest the department should get this information and sabotage his plans. This often led to a complete breakdown of communication between a departing scientist and his friends. In recent years, even those who are sent abroad for higher training in the interest of the department are penalised in terms of promotions and housing.

This is not all. The service conditions of scientists at BARC have been constantly deteriorating. Between 1972 and 1979, there was an arbitrarily imposed moratorium on confirmations. As usual, a very small number of well-connected scientists were confirmed, just to demoralise the rest a little more. The Bhabha Atomic Research Centre Officers' Association (BARCOA) had to seek the intervention of the then Prime Minister to get the scientists' right to confirmation restored in 1979. In the meantime, many were unceremoniously thrown out. The norms for promotion which have been stubbornly kept secret from working scientists are being gradually tightened. Over the last decade, more and more effective powers over scientists' careers have been transferred to the bureaucracy and these have been frequently misused. For all this, the science managers have been directly responsible. The structure of pay scales and hierarchy is so bewilderingly complex that in many cases the net result of two promotions to a scientist can be his reversion to the starting scale! Can this happen any-

(Contd. on p. 24)

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Electronics — watch the pitfalls

THE Central Government is studying the Sondhi Committee report on electronics. The committee, headed by Mr. Mantosh Sondhi, secretary to the Ministry of Steel, Mines and Coal, was set up by the Janata Government in December 1978 following a call by Dr. Atma Ram, then Chairman of the National Committee on Science and Technology, for a review of the functioning of the Department of Electronics (DOE) and the Electronics Commission. The report was submitted in December 1979 to the caretaker government headed by Mr. Charan Singh, who appointed a committee of secretaries to process the report for approval by the Cabinet. There was a considerable effort to get the report approved early by the former government, but the elections intervened.

What did the report say, anyway? The report has not been released officially, but, in essence, it concluded that the only way to promote the electronics industry was to scrap unnecessary controls and regulations. The committee found that the Electronics Commission was working more as a regulatory agency than a promotional body and recommended its replacement by an electronics development commission (EDC), a "think-tank" which would function purely as an advisory body. It was this recommendation that was resented by the Scientific and Technical Officers' Association of the DOE. The government has now decided not to alter the basic structure and responsibilities of the Electronics Commission.

On several other recommendations of the committee, the government is yet to decide. And one hopes that not all the recommendations are shelved. The committee has, for instance, suggested some sweeping changes in industrial approval, fiscal and export policies that may indeed stimulate a faster growth of electronics in the country. There are, however, some recommendations that appear to be biased in favour of private sectors and foreign multinational companies (MNCs).

Basically, the committee made the following recommendations: (i) the Electronics Commission is to be replaced by the EDC, free from the executive and policy-making responsibilities of the Electronics Commission; (ii) an electronics approval board (EAB) and an electronics research and development organisation (ERDO) are to be set up under the DOE; (iii) a research and development (R and D) board under the DOE to guide, direct and ensure co-ordination of R and D activities in the country; and (iv) a planning and co-ordination group under the DOE to co-ordinate growth and development of public sector electronics units.

The EAB is to act as a single agency with powers of approving industrial ventures and foreign collaborations. It will have the powers now being exercised by the Licensing Committee, the Foreign Investment Board, the Capital Goods Committee, the Technical Development Fund Committee, the Committee of Joint Ventures Abroad and the Import Licensing Committee. The EAB will clear industrial applications in 45 days. While making R and D compulsory for the private sector, the committee has also recommended several financial incentives: exemption or reduction in customs and excise duties, concession in income-tax for the electronics components industry and tax holiday for units in the Santa Cruz export zone.

While the tax incentives and the single point approval for industrial applications are to be welcomed, some other measures proposed may indeed kill indigenous R and D. Take, for instance, the recommendation for opening up the country for foreign collaboration in virtually all areas of electronics, including telecommunications. This, apparently, is an attempt to copy Taiwan and South Korea where almost every electronics item is made by foreign firms.

Should India follow this approach? No doubt, it may result in bigger exports of consumer items, but it will also kill indigenous R and D. Telecommunications equipment is presently made in the public sector. Opening the doors for the private sector will only bring in the multinationals like Philips or the Siemens. There is no substitute to the indigenous development of the electronics technology, particularly high technology electronics needed by the defence or the space departments. Can our armed forces or space and nuclear scientists depend on foreign firms to produce critical electronic components? Similarly, the committee's suggestion for expanding the licensed production capacity of FERA (Foreign Exchange Regulation Act) and MRTP (Monopolies and Restrictive Trade Practices) companies—in preference to setting up new units by others—is also a recommendation in favour of multinationals.

The main drawback of the Sondhi Committee report is the near-total absence of any major recommendation for strengthening the public sector units which now produce two-thirds of the electronics equipment particularly needed in the strategic sectors of defence, space and telecommunications. While conceding that the committee has made some valuable suggestions for speeding up the growth of the electronics industry, whether unlimited foreign collaboration is necessary to achieve this growth and its long-term implications on indigenous development and self-reliance are questions that need a careful scrutiny.

K. S. JAYARAMAN

Dr. Jayaraman is Science Correspondent of the Press Trust of India, New Delhi.

The Sondhi Committee report

The Indian scene in electronics, even after two decades, is marked by a slow rate of growth. Production in 1978-79, covering all sectors of electronics, was of the order of Rs. 620 crores—an insignificant share of the global production. This is unfortunate, as the most important of all resources in this field is possessed by this country, namely an abundance of skilled and employable manpower and a high degree of technological competence. It is a matter of real concern that we lose every year one of our most valuable assets, namely our electronics engineers in large numbers to other countries. Investment, production and employment generation have not been as high as expected, partly because of the elaborate structure for screening and rigid control on all expansion or new capacities and approval of projects in this sector. The emphasis so far seems to have been more on regulatory rather than on development and promotional aspects.

* * *

Immediate measures are necessary to ensure that indigenous production of contemporary computers and peripherals makes rapid strides so that the range of computer systems produced in the country does not continue to be restricted. The strategy for the development of the computer industry has to give first priority to mini-computers and microprocessor-based systems, costing not more than Rs. 50 lakhs with maximum flexibility in the import of components. Second priority has to be for medium computers costing more than Rs. 50 lakhs. The large computer systems will naturally have to take third priority.

Banking on brilliance

SOME ARE born great, some achieve greatness... and, by early next year, would we have—in addition to these well-known categories—the some who are expected to be born with genes for Nobel prizes thrust into them?

Robert K. Graham, the California millionaire who has set up an exclusive sperm bank for Nobel laureates, has been quoted as saying, "We are not thinking of a super-race, we are thinking in terms of a few more creative, intelligent people who otherwise would not be born." So, with that in mind, a brief discussion of some points that seem relevant.

True, some people may commend Graham on his attempt to increase the number of highly intelligent people in a world beset with ever-increasing problems. But will a sperm bank for Nobel laureates provide the means? And if it ever does, will an increased IQ alone guarantee accomplishment?

Five Nobelists are known to have already made 'deposits' at Graham's bank of which only one has been named: William Shockley of Stanford University, a co-winner of the 1956 physics prize. Shockley is also known for his controversial genetic theories of intelligence, especially his proposition that the white races are inherently more intelligent than the blacks, but that's another story. The important thing here is that Shockley, at the ripe age of 70, could be typical of many living Nobelists who are potential contributors to the sperm bank.

Sperm banker Graham's belief, that an average Shockley sperm must contain the genetic material to produce a creative, intelligent kid, overlooks the fact that any person, however high his IQ may be, could also carry undesirable genes. Besides, there are the increased risks of chromosomal defects associated with reproduction in advanced age. Perhaps the most dangerous of these, established only recently, is the risk of mongolism in the offspring. Also known as Down's syndrome, this condition was previously attributed mainly to the mother being past 35. But recent Danish and Japanese investigations have shown that the risk of producing a Down's baby is also high if the father is around 50, and that it is very high if he is over 55.

Although there are many cases of scientists receiving Nobel prizes early in life, the majority of Nobelists received the award after 50. The average age at which 92 American Nobelists studied by Harriet Zuckerman (*Scientific Elite*, 1979) received their prizes was 51. So, even if an average Nobelist donates his sperm the moment his prize has been announced, or let us say, just when he's back from Stockholm after the ceremony, chances are he could carry unhealthy sperm.

There is also the role of the woman who will bear the child. Here, one good point will of course be that a few women who never had the luck to marry a Nobel laureate will get a chance, at least to bear the child of a laureate, which, considering American fetish for fads and the uniqueness of the sperm bank, will involve no small prestige anyway. . Graham reserves the Nobel sperms to impregnate only very intelligent women. Intelligence, presumably, will be ascertained by subjecting interested women to psychological IQ tests, which are themselves often criticised as being crude and impractical, even racist. As such, any attempt at 'selective breeding' cannot abandon completely the same fears expressed by George Bernard Shaw to the stunning young woman who came to him with the proposition that if they got married, their child would have her body and his brains. "And what if it turns out to be my body and your brains?" asked the playwright.

On the other hand, even if the woman does happen to be extremely intelligent, there is the statistical probability known as regression to the mean. That is, if a very intelligent (or very dull) couple get married, the odds are that their children will have IQs that are about average. Again, there is always the possibility of either partner carrying a recessive gene passed down by an abysmally dumb ancestor, for if genetics played the great part in determining IQ levels, many genes must be involved.

That takes us to a bit of statistics regarding the backgrounds of the Nobelists. Since 1901, when the Nobel awards were first made, only five scientists have themselves had a father who was also a winner. All the five, obviously, had every opportunity to socialise as well as work in an environment conducive to the high standards of work and study which must go behind the making of a Nobelist. Such conditions could as well be obtained by working under a first-rate teacher who is not even a blood relation. Indeed, more than half the total number of all Nobelists in science won the prize after they worked under the guidance of an older Nobelist. Enrico Fermi, for instance, has six American laureates to his credit, while Ernest Lawrence and Neils Bohr each have four. Hans Krebs, a 1953 co-winner of the Nobel prize for medicine (see SCIENCE TODAY, March 1968, p.30), can trace his 'professional ancestry' back through his teacher and teacher's teachers (all Nobelists) up to A. von Baeyer (1835-1917). Von Baeyer, again, was the product of a lineage that can be traced right back to Claude-Louis Berthollet (1749-1822) via Kekule, Liebig and Gay-Lussac, in that order, who would all most certainly have been Nobelists, had the prizes existed then.

Contrast all that to the miniscule minority of father-son pairs. To quote Zuckerman again: "Nobelists are life peers in the world community of scientists. Having been recruited into the aristocracy of science on the basis of their own achievements, they can only pass on to their children an enlarged access to opportunity. They cannot of course ensure that their own offspring will enter the ultra-elite of science."

Even where genetic influences in determining intelligence have been shown using the most highly regarded tests, bold conclusions can be made only with at least one major qualification—that the evidences apply only to large statistical groups of people and not to particular individuals. For instance, the effects of environment and opportunity are clearly shown in tests given to American blacks and whites: average IQ scores are always higher among blacks in urban New York and Illinois than among whites in the poor southern states of Mississippi and Georgia. The factors accounting for intelligence are not all known. Bertrand Russell, himself a Nobel laureate and one of the most versatile minds of our age, wondered whether the extreme intelligence of certain individuals resulted from a stray atom in one of the body's complex organic molecules vibrating a little differently. D. H. Lawrence wondered why his hand, or some other part of his body, is not considered as important as his head for the cognitive and creative process. Could that be why detailed studies of Albert Einstein's brain to find a clue to his genius produced no results?

We know that selective breeding of cattle can produce physically better offspring. The same may be true of humans. But using that formula to breed intelligence does not itself seem an intelligent idea.

MOHAN SIVANAND

Mohan Sivanand is on the editorial staff of SCIENCE TODAY.

Science Shapes Life

PLANT INTERFERON

When viruses infect an animal, the host's cells respond to produce a protective chemical. This antiviral chemica is a protein called interferon. Interferon is now mankind's dream drug against all viruses; with sufficient quantities of interferon, it is hoped, we may even be able to tackle some types of cancer in future. Genetic engineering techniques seem to be making the largescale production of interferon possible. Charles Weismann of the University of Zurich has already successfully trained bacteria to make human interferon.

So far interferon had been reported only from animals. But now scientists at the Hebrew University, Jerusalem, Israel, claim to have found a similar compound in tobacco plants. Ilan Sela and colleagues even report characterising and purifying this plant antiviral agent.

The plant chemical acts in the same way as the animal-derived one to check the spread of viral infection. It is a phosphorylated glycoprotein. A product of the N-gene, the gene for viral resistance, the plant interferon's activity is controlled by polymerised adenosine as in an animal. Four or five molecules of the interferon per cell is said to be enough to make the plant resistant to viral attack. The N-gene has been bred into several tobacco varieties.

Plant interferon might help in agriculture but, since it does not act on animal viruses, it is unlikely to have any use for animals.

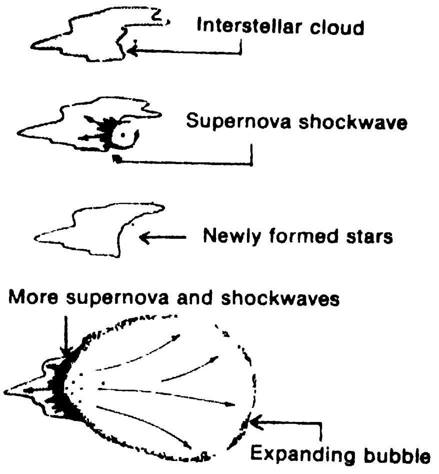
BUBBLES IN THE UNIVERSE

Two US astrophysicists, Webster Cash and Philip Charles, have discovered a hot gaseous astronomical bubble in the Milky Way. And what a bubble it is—some 1,200 light years in diameter and with a temperature of two million degrees centigrade.

How did the bubble form? Charles and Cash have an explanation. The bubble is partially hidden from observers by a dense gas cloud known as the Great Cygnus Rift. The presence of this rift itself provides a clue.

The astrophysicists suggest a sequence of events, of which the first was possibly a supernova explosion behind the rift. This explosion triggered off a stellar chain reaction, which compressed the rift gas to form several stars. Some of these stars themselves got metamorphosed into supernovas, creating more shockwaves and yet newer stars. It is the ensuing shockwaves that created an expanding bubble.

Indeed this is the first time that a bubble has been spotted. Scientists had seen parts of it but had never got an integrated picture because of the obscuring caused by the rift. Scrutinising X-ray pictures by NASA's High Energy Astronomical Observatory (HEAO - 1), Charles and Cash found this strange object 6000 light years away on an arm of the galaxy adjacent to the arm in which the solar system is.



The supernova blows a bubble with a cloud

Cash and Charles are excited. They think there could be more bubbles in the universe and plan to look for them.

LESS DDT IN INDIANS?

The recent finding of a group of researchers seems to indicate that Indians, in Delhi at least, do not have as much DDT in their bodies as was previously believed. M. Bhaskaran, R. C. Sharma and N. K. Bhide of the Department of Pharmacology, All India Institute of Medical Sciences (AIIMS), New Delhi, who used a simplified method developed by them involving colorimetry, see the range of DDT content in the samples analysed by them to be well within the safe limit. It also compares favourably with the figures reported for many advanced countries.

DDT is a toxic substance and has great affinity for fat. In addition, its high stability can result in its steady accumulation in human adipose (fat) tissues. A paper published in 1965 by E.W. Dale and co-workers (*WHO Bulletin* 33 471) had reported an average level of 31 ppm, with a range of zero to 189 ppm, in 88 human fat samples in the Delhi area. This finding for Delhi found support even as late as 1973 from Indian researchers who obtained figures near 30 ppm.

The AIIMS scientists, who describe their findings as well as their method for analysis (which they claim is about as accurate as gas chromatography) in two separate communications (*Indian Journal of Experimental Biology* 17 1367 and 1390), studied 14 peritoneal fat samples from postmortem cases at the AIIMS hospital. The subjects ranged in ages from 18 to 80 years, all of them being from or about the Delhi area. The researchers observed an average "total" DDT level of only 4.7 ppm with a range of 2 to 10.1 ppm in the samples studied.

The "total" DDT level expresses the sum of the DDT and DDE (1, 1-dichloro-2, 2-bis (p-chlorophenyl) ethylene) levels in human fat. DDE is a qualitatively important metabolite of DDT that occurs with it up to 40 per cent by weight. Since their simplified method could analyse only the DDT content, they had their observed values corrected to obtain the "total" level. And, to check the validity of their method, they had two of the samples analysed once again by gas chromatography. The figures obtained from both methods agreed.

What is of interest is the great difference in the values of DDT levels observed now as compared to those of 1965 and 1973. The AIIMS scientists say, "It is difficult to explain the difference... particularly because in all these studies, human fat samples were collected from the same area, Delhi."

And, the stability of DDT is so good that its levels in human fat can remain unchanged for several decades. In the USA, for instance, it has remained fairly constant since 1951. Besides this, the AIIMS scientists feel that the present safe limit (20 ppm) may only be valid for the advanced countries. "But for the much less healthy populations of the developing countries of the tropical zone, the safe limit may not be the same. This... needs further study", they say.

PRENATAL STRESS AFFECTS REPRODUCTION

Do not tell a pregnant woman anything that will upset her, they say. Is there any truth in this old wives' tale? Psychologist Lorraine Roth Herrenkohl of the Temple University, USA, has found that when pregnant rats were subjected to stress their female offspring had trouble getting pregnant and also in maintaining pregnancy.

Prenatally stressed rats weighed less at birth and were more likely to die during infancy.

The exact mechanism by which maternal stress affects the fetus is not clear. But it is known that stress brings about changes in the adrenal secretion and also that prenatal sex differentiation is accompanied by large amounts of steroids, some of which secreted by the adrenal. Prenatal stress might interfere with the exchange of gonadal and adrenal hormones between mother and child, or it might affect hormonal balance in the fetus at a critical stage of development. Herrenkohl suggests, disturbances in maternal adrenal hormones during sexual differentiation disrupt the reproduction in female offspring by decreasing sexual receptivity, or by inducing gonadotropic or ovarian irregularities or both.

BE CHEERFUL TO AVOID COLDS

On an average you catch cold about seven times a year, according to experts of the Common Cold Research Unit (CCRU), Salisbury. However, you hardly suffer from this infectious disease as often. Most colds vanish after a few sneezes and sniffles. What makes some of them more, and some less catchy?

Richard Totman of the CCRU has found one clue. He infected 52 volunteers with cold viruses to find out what are the susceptibility increasing factors. Prior to the experiment, all volunteers were physically checked, their blood antibody levels were noted and then medically examined. Preinfection antibody levels in blood is used by clinicians to predict the severity of a cold. Another aspect Totman looked into was the mental make-up of his volunteers; psychologists assessed their level of stress due to work and social activity during the previous six months; introversion, extroversion and neurotism were also noted. He found that preinfection antibody levels alone are not sufficient to predict the virulence of an attack. Stress and introversion make a person more susceptible to the disease.

What set Totman to look for psychological factors was his previous study of heart diseases and their relation to stress. Also, not everyone responds similarly to viruses; some people seem immune even to new viruses. This might mean psychological factors are involved, he reasoned.

The severity of the infection was carefully monitored. The subject's had not been allowed to get close enough to pass on the germs. The nasal wash was tested in tissue culture for activity (this is called virus shedding test). Virus shedding, it was found, was 26 per cent due to stress activity change factors. Preinfection antibody levels accounted only for the 14.9 per cent. Also, introversion reflected the severity of the cold. The other test, measuring the symptoms, showed that stress activity loss (not change) was significant in the severity of symptoms.

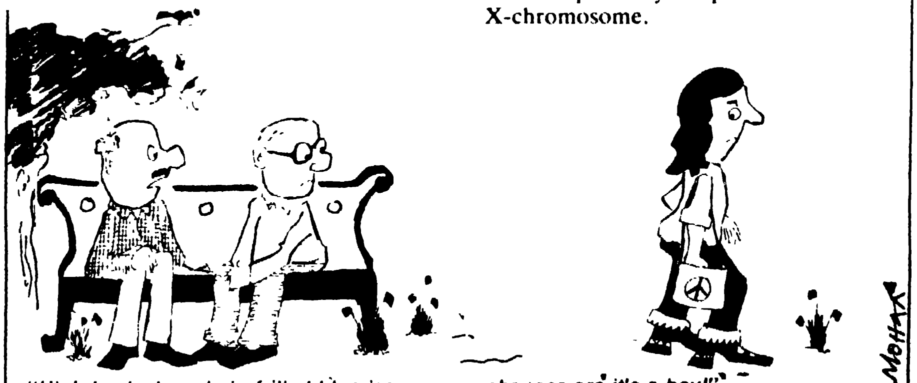
So another way to prevent a common cold, apart from vitamin C, seems to be cheerfulness. Good adjusters, according to Totman, can take stress in their stride. Psychological factors decide, to a great extent, whether or not we can stop the virus from multiplying.

WHY CAN'T MEN BE LIKE WOMEN?

Because women have two X-chromosomes and men have only one and that makes men less resistant to certain diseases. Research has shown that some human immune regulatory genes reside on the X-sex chromosome. And since women have two X-chromosomes they probably have a double dose of genes which could result in a double dose of immune fighters. Fewer women are susceptible to certain diseases like *E.coli* infections, parainfluenza respiratory infections, polio virus infection of the central nervous system, rotavirus gastroenteritis and even some cancers. Women, it has also been found, produce more antibodies against *E.coli* and polio virus and have more IgM and IgG antibodies than men do.

David T. Purtilo and John L. Sullivan of the University of Massachusetts Medical School, USA, ascribe this entirely to the extra X-chromosome. But this factor has a few drawbacks. The superior immunity may work against them leading to autoimmune diseases—diseases in which the body turns against itself—like rheumatoid arthritis, myasthenia gravis and lupus erythematosus. In fact these diseases do strike women more often than they strike men.

Why do women need excessive immunity? Purtilo and Sullivan suggest this could have an evolutionary reason. Women's immune system is suppressed during pregnancies so that the baby is not rejected as 'foreign'. So that the immunity is not completely lowered, leaving the women open to infection, women probably acquired the extra X-chromosome.



"High heels, long hair, frilled blue-jeans —so chances are it's a boy!"

IMPOTENCE IS NOT ALWAYS PSYCHOGENIC

The earlier belief that 95 per cent of the cases of impotence arise from psychological causes is not true, say Richard F. Spark and colleagues of the Beth Israel Hospital, Boston, USA.

Psychotherapy has not always successfully cured impotence. The rate of failure is quite high, which means other factors could be responsible too. So Spark thought it worthwhile to investigate the physical factors as well. For example, erectile potency depends also on neurological, vascular and hormonal systems apart from the healthy psyche. When Spark and his team screened the testosterone levels of 105 impotence patients, they found that 37 patients had previously unsuspected hormonal disorders. Once treated for these disorders, 33 patients were cured of their impotency.

CURE FOR ALLERGIES?

About 34 years ago Australian scientists had found that in guinea pigs allergic reactions produced histamine and another unidentifiable complex substance. This fugitive compound which is responsible for severe allergic reactions has now been synthesised by Elias J. Corey and colleagues at Harvard University, USA, using the sugar ribose as the starting material. So far, it had not been possible to obtain the compound because it is found in very minute amounts in the body and has a very unusual structure.

The newly synthesised compound has been named leukotriene-C: 'leuko' from leucocyte, a type of white blood cell in which it is found, and 'triene' because it has a set of three double bonds. Leukotriene-C has a three-amino-acid peptide called glutathione.

Leukotriene constricts small airways of the lungs resulting in wheezing and laboured breathing. Histamine, which is also produced during allergic reactions, constricts air passages but its reaction time is much faster and short-lived than the slow-acting and longer-active, but more powerful leukotriene.

Now that the substance has been identified and its structure determined, it will be easier to tailor anti-leukotriene compound in order to tackle allergies.

AND NOW ELECTRIDES?

A chemical compound is one of the most fundamental and cherished concepts in chemistry. However, recent studies by J.L. Dye and his group in department of chemistry, Michigan State University, USA, are undermining that simple concept in a way to include electrons, in effect, among the chemical elements. Several compounds, made up of alkaline metal elements and electrons, have been made and studied by Dye and his team.

These compounds have been deliberately called 'electrides'. The analogy is also precise. Instead of the expected element—such as fluorine or chlorine—forming a salt, the task is performed by an electron.

Lithium electride, which is one of the compounds most extensively studied by this group, has been found to have two forms. Above 228°K, the electrons are delocalised and the material exists in a high-conductivity metal-like state. The electride phase exists at a temperature below the sharp transition temperature of 225°K. In this new low-conductivity state, the electrons get locally trapped, forming large elementless-anions.

The progress of work on electrides is hampered because they are highly unstable. They have to be kept at a low temperature. They also cannot be exposed to light and the atmosphere. Also, instead of crystallising, the electrides form a kind of mud on the vessel walls.

HOW FLU VIRUSES KEEP US GUESSING

Gradual as well as drastic genetic changes in the virus causing influenza render previous immunity ineffective. Antigen drift, a gradual process, is very common among them. Antigenic shift, a more drastic change, occurs about once in 10 years. And the emerging organism is totally new. But James Young and Peter Palese at the Mount Sinai School of Medicine have found that when two strains of flu viruses cohabit, the new emergent form may have the coat of one strain and the genetic material of the other.

The worldwide epidemic of 1977 brought to light that the causative virus, the strain H1N1, was similar to the one preserved from 1950 epidemic. It was surprising. Palese ruled out 27 years of normal passage in man. Since a flu virus changes about four per cent of its genetic material every eleven years in passing from person to person, scientists felt that the H1 N1 was somehow "frozen". One scientist jocularly suggested that an infected person might have fallen into a glacier thus preserving the strain.

Young and Palese monitored all the minor variants of the currently prevalent strain causing influenza. The H1N1 strain changed more in a six-month period in 1977 than the "frozen" had from 1950 until its re-emergence in 1977. The virus has antigenic two-coat proteins: hemagglutinin (H) and neuraminidase (N). The scientists studied the minor variants to see if the superficial changes in their surfaces were accompanied by more remarkable changes elsewhere.

They performed a crude chemical analysis of the entire virus by digesting all its coat proteins and all its nucleic acid into fragments, and compared the fragments from different strains. By comparing the digests of the last pandemic strain H3N2 with that of its predecessor, H2N2, they concluded that the H3N2 strain could have derived from the combination of H2N2 and another virus.

They then compared the original H1N1 strain with the variant H1N1 and H3N2, which is still at large. The variant fragments appeared to be a mixture of the original H1N1 and the H3N2 strains.

As some patients are infected with both the strains simultaneously, the possibility for such a hybridisation is strong, Palese and Young say. Hybridisations complicate the task of providing an effective vaccine, since the rate and the direction of change are less easy to predict. Therefore, vaccines will have to be made specifically for each epidemic.

MAN-APE ANCESTOR

That man and apes are related is no longer disputed. But what did the common ancestor of these look like? According to primatologist Elwyn Simons and anatomist Richard Kay of Duke University and paleontologist John Fleagle of State University of New York (both in the US), the patriarch of the man-ape lineage was a small cat-sized, skittish-looking, vegetarian tree-dwelling creature.

The remains of the great ancestor *Aegyptopithecus* were found in the Fayum Depression in Egypt, in 1977. The fossils of jaw fragments when reconstructed showed that they belonged to a diurnal creature which lived in fairly complex societies where the males competed for dominance. The daytime active primates have, as a rule, more complex societies than the nocturnal ones which are usually solitary animals. The fossils also showed that there was a size difference between the sexes. The males weighing about five kilograms were about one kilogram heavier than the females.

The *Aegyptopithecus* lived some 30 million years ago, that is 10 million years before the primitive man *Dryopithecus* evolved. A complex social life indicates that it was an intelligent animal; to be social, animals must be intelligent enough to distinguish the member of the troop and also recognise potential enemies—dangerous apes—from other troops.

Earlier, scientists had thought the *Aegyptopithecus's* contemporary, *Propliopithecus* which had small canine teeth and premolars, was the ancestor of primitive man since small canines and premolars set man apart from ape. But *Aegyptopithecus*, it appears, resembles primitive man more closely.

FOOT-AND-MOUTH DISEASE VACCINE

When genetic engineers talk about tampering with *E. coli*, there is always a hue and cry. This is because *E. coli* is a normal resident of the human intestines and if a mutant strain escaped, the result might be disastrous. But many scientists think otherwise. Working with pathogens, they say, is more dangerous.

The Recombinant DNA Advisory Committee (RAC) of the National Institutes of Health, USA, which meets quarterly to update guidelines has now approved of cloning the foot-and-mouth disease (FMD) virus in *E.coli*. This had previously been banned from recombinant DNA research because the virus is highly infectious.

The FMD affects cattle, sheep, swine, horses and some other hoofed animals. The disease has no cure and there is no satisfactory vaccine. The only way of prevention is to kill and carefully dispose off all affected and exposed cattle. With the relaxation in guidelines, Howard Bachrach and colleagues of the US Department of Agriculture at Plum Island, plan to produce subgenomic fragments of the rival RNA and clone the various parts of the virus. Their main precaution against accidents will be to clone small segments, so that no single segment is long enough to cause infection. Each short segment will be tested on highly sensitive tissue to make sure they are not infectious.

The next step will be to analyse what each segment codes for and which segment codes for the protein VP_3, which is thought to stimulate immune response in animals. The second stage of the experiment is to be carried out by Genentech, a private company.

Not all scientists are sure the precautionary measures taken are sufficient; some clones might end up carrying multiple inserts so that a larger fraction of genome than intended might get cloned. Richard Goldstein, associate professor of microbiology at Harvard, USA, is one of the pessimistic scientists. As to the deluge of 140 letters that came in response to the lowering of guidelines, Goldstein scoffs at them calling it "a well orchestrated letter-writing campaign originating at the University of Wisconsin .... (which) demonstrates the lengths many scientists are willing to go (to) push for the lowering or doing away with guidelines. This is a political campaign which may backfire in case of an accident.... We will all suffer because of the self-interest of a minority of the scientific community."

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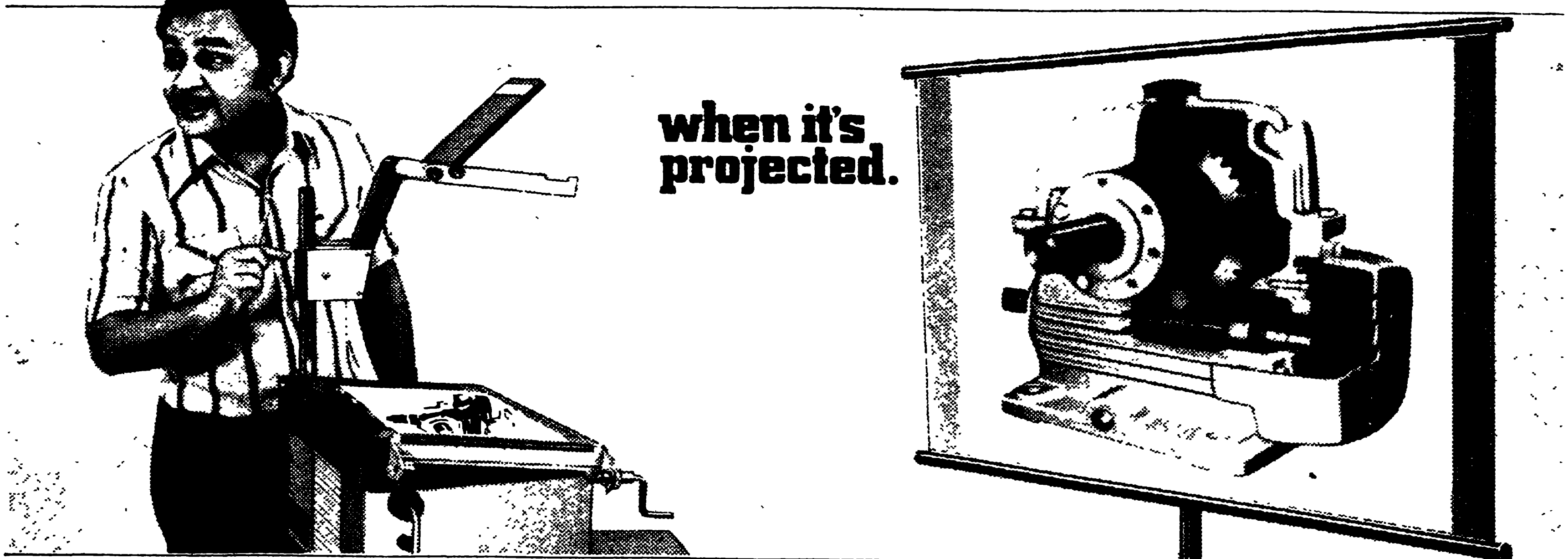

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Helium probe for the earth's secrets

Patterns of helium distribution in the earth provide a new tool in understanding the evolution of our planet

S. K. Gupta
P. Sharma

HELIUM, first of the rare gases, was discovered in 1868 in the spectrum of the sun's chromosphere. In 1895, Sir William Ramsay identified it on the earth in a radioactive mineral of uranium. Fairly large deposits of heliogenic gases were first discovered in 1907 by H.P. Kedi and D.F. Macfarland in central parts of the USA following their analysis of a sample from a natural gas well; the well had yielded a gas that could not be burnt except by first heating it to a high temperature. Today, helium is helping scientists to probe the interior of the earth.

In stars, for example, our sun, helium is formed by nuclear reactions involving conversion of four protons (burning of hydrogen) into a helium nucleus. Hydrogen is the lightest and the most abundant element in the universe. About 76 per cent of the mass of the universe now is made up of hydrogen and 23 per cent helium; all other elements together make up a mere one per cent. It is now known that in our solar system, the sun and the atmospheres of heavier planets like Jupiter and Saturn, consist mostly of hydrogen and helium. The atmosphere of the earth, on the other hand, contains only about 5.2 parts per million (ppm) of helium and the planets Mercury and Pluto appear to have no atmosphere at all. It is reasonable to assume as a first approximation that, in the initial stage of its evolution, the solar system had a uniform composition of all the elements and their isotopes. We term this composition *primordial*.

What then is the reason for the loss of lighter constituents from small planetary bodies? Lighter constituents of the atmosphere, by virtue of their thermal velocities above a certain threshold, known as the escape velocity (which depends on the mass of the planet and the molecular weights of the constituents), can escape the atmosphere of a planetary body. Besides helium, hydrogen is also lost from the earth's atmosphere. But since hydrogen forms a very stable compound, namely, water, we find a large part of the original hydrogen still on the earth as water in the lakes, glaciers, groundwaters, oceans and water vapour in the atmosphere.

Helium is also produced in rocks and minerals on the earth due to radioactive decay of uranium (U) and thorium (Th) An alpha particle is, in fact, a helium atom devoid of electrons. It is, therefore, sufficient for an alpha particle to capture two electrons from the surrounding medium to be converted into a neutral atom ^{4}He. Helium has another isotope ^{3}He, which is formed when a tritium (^{3}H) atom decays.

^{3}He and ^{4}He are also injected into the earth's atmosphere as a component of cosmic rays, both solar and galactic. It is believed that the present helium concentration in the atmosphere of the earth is an equilibrium value between the flux of radioactively produced helium from the crust, influx due to cosmic rays and its loss due to thermal escape to the interstellar space.

Until relatively recently it was believed that most of the primordial helium of the earth has already been lost to the outer space during the past 4.6 billion years since the earth was formed. The large quantities of helium often seen associated with some thermal springs and volcanic gases was believed to have come from radioactive decay. In 1969, Harmon Craig of the Scripps Institute of Oceanography, USA, and his associates discovered a 10 per cent enrichment in ^{3}He/^{4}He ratio in water samples from the Pacific Ocean. These samples were derived from depths below 4,000 m in the southern end of the Kermadec Trench in South Pacific, an area of known sea-floor spreading (SCIENCE TODAY, January 1971, p.22). This discovery led to the then completely speculative hypothesis that 'primordial' helium enriched in ^{3}He relative to terrestrial atmospheric helium was injected into the oceans at the crests of oceanic rises where new crust is being formed. The association of a primordial mantle helium component with sea-floor spreading centres in the ocean basins has since been established.

Tectonic model of the earth

With a view to appreciating the significance of these and other observations, discussed later, let us first describe a tectonic model of the earth. Basically, the model is rather simple and largely based on seismological evidence. From the surface to the top of the core (Fig.1), the earth is divided into three layers : (1) the *lithosphere*, a rigid layer approximately 100 km thick, including the crust and the uppermost mantle, (2) the *asthenosphere*, a plastic layer of little effective rigidity, perhaps as much as several hundred km thick, and (3) the *mesosphere*, extending from the base of the asthenosphere to near the core, probably with significant rigidity.

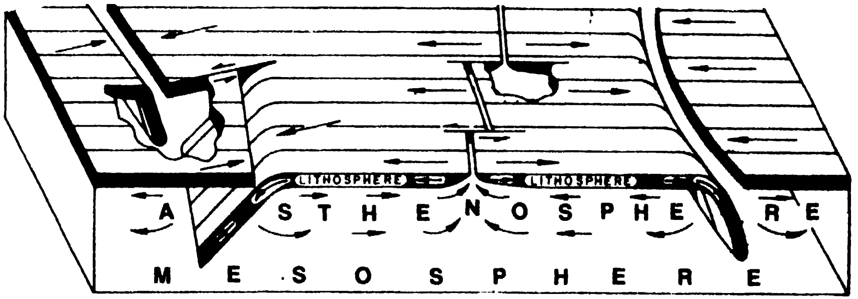


Fig 1 A model of the earth's interior from the surface down to the top of the core. The lithosphere, comprising the crust and uppermost mantle, is visualised as consisting of a number of rigid plates that move about relative to one another due to convection currents in the underlying, relatively plastic asthenosphere

The lithosphere plays a leading role in this model. It is broken into large plates, called *lithospheric plates*, that move about relative to one another, like rafts on the denser, hotter and more fluid rock of the asthenosphere.

The lithospheric plates have ten major sub-divisions, besides several minor ones (Fig.2). These plates move horizontally, and this constitutes the principal tectonic movement of the earth. In areas where the plates converge, the horizontal motion can be transformed into inclined and vertical movements of the plates. The "cool" lithospheric

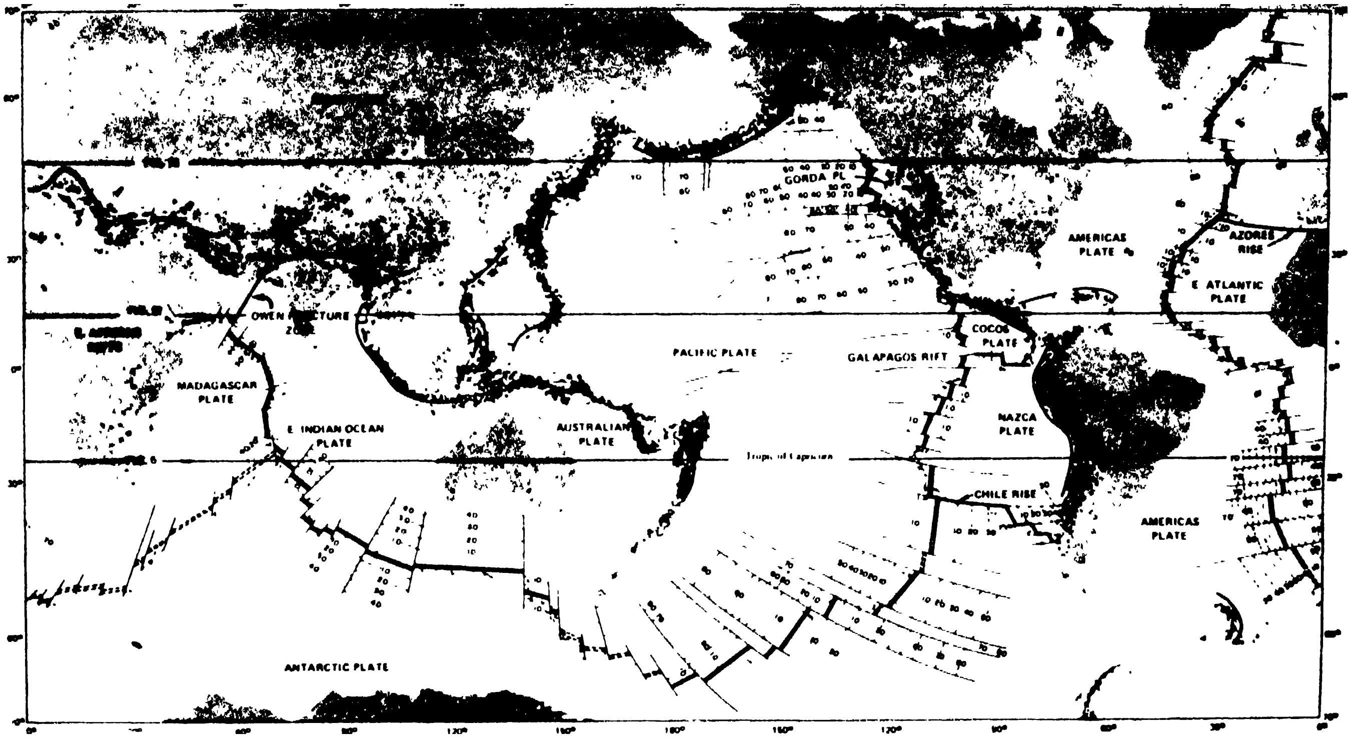


Fig 2 Worldwide distribution of epicentres of all earthquakes (during 1961-1967), depth 0-700 km The present seismic activity is concentrated along narrow zones (inferred as plate boundaries) of the earth, separating very broad regions of seismic quescence. The numbers represent apparent ages of sea-floor (in millions of years) obtained from magnetic anomalies which are symmetric about the ocean ridges (From "Sea-floor spreading" by J R. Heirtzler Copyright©1968 by *Scientific American* Inc. All rights reserved)

plates are relatively free of tectonic activity. The geological and tectonic activity is thus mostly concentrated along plate boundaries.

The activity at boundaries between plates depends on the type of boundary. At a *divergent boundary,* two plates are pushed apart because the hot fluid magma rising from the mantle forms new crust that cools and spreads outwards in both directions. Ocean ridges, where new sea-floor is created, lie along such axes of spreading. At a *convergent boundary,* two plates meet. In a *subduction zone,* one plate plunges under the other and returns to the hot asthenosphere. In a region of outright collision, parts of the crust are thrust up to form mountains. At parallel boundaries, two plates move edge to edge. Thus plate boundaries are marked by tectonically active zones — the island arcs, the ocean ridges and the major transcurrent faults. Explosive volcanism is found only at sites where descending crustal material penetrates the mantle.

Many geological and geophysical data are difficult to account for except within the above general framework of global tectonics. For example, it seems particularly important that the present seismic activity is concentrated in remarkably narrow zones of the earth, separating very broad regions of relative seismic quiescence (Fig.2). Further, deep earthquakes are entirely absent in areas of apparent crustal spreading and are concentrated in regions of crustal convergence—where they closely correspond to oceanic trenches and active volcanoes.

Many hypotheses have been put forward to explain the driving mechanism of plate tectonics. One view is that the lithospheric plates are pushed by the weight of spreading ridges or pulled by a heavy downgoing slab at subduction zones. Another hypothesis is that it is the motion of plates in the lithosphere that causes flow in the asthenosphere (the movement of lithospheric plates can be caused by sliding motions downwards and across the asthenosphere under the influence of gravity). However, most earth scientists agree that the plates are dragged along by currents flowing in the underlying asthenosphere. In this model, it is visualised that largescale convection currents rise in the mantle, producing an ocean ridge with a central rift valley. As the slowly moving material flows at the top of the asthenosphere, it drags the rigid lithospheric plates along with it.

Table 1. Average Value of ^{3}He/^{4}He Ratio

Samples	**^{3}He/^{4}He ratio**
Radioactive minerals	$\sim 10^{-8}$
Average crustal rocks	$\sim 10^{-7}$
Atmosphere	$\sim 10^{-6}$
Mantle-derived sources	$\sim 10^{-5}$
Meteorites	$\sim 10^{-4}$

The evidence for the existence of convection currents in the mantle is indirect; they flow too deep in the earth and too slowly — a few centimetres a year — for direct observation. Perhaps the strongest indication of the existence of mantle convection currents comes from surface heat flow measurements.

There are many indications that the earth's interior is hot, the most obvious being an erupting volcano. Heat flows from a warmer zone to a cooler one; it can, therefore, be inferred that, since temperature increases with depth in the earth's crust, there is a flow of heat outward from the earth's interior. Data and statistical analyses of heat flow measurements made in deep mines, bore holes and by specially designed probes over the ocean areas indicate that the mean heat flux through the earth's surface is 1.5 micro calories per sq cm per second with no significant difference between the mean for continental and oceanic regions. This result is surprising in view of the large difference in crustal structure between these two fundamentally different regions. Though *in situ* heat generation due to radioactivity may provide a considerable share of heat in the thick continental crust, this is almost certainly not so in oceanic regions. There the thin crust, about 5 to 10 km thick, provides only about 10 per cent or less of the observed heat flow. Therefore, the mantle and/or the core are the most likely sources of much of the heat flow under oceanic regions. Further, recent results have indicated that the flow of heat is generally more along the oceanic ridges, exceeding two to eight times the average flow elsewhere on the ocean floor. The heat flow pattern generally observed near subduction zones, and particularly well documented for Japan (see, for example, Henry Pollack and David Chapman, "The flow of heat from the earth's interior", *Scientific American*, August 1977), is that it is low near the oceanic trench and high towards the landward side of the arc. These observations can be explained on the basis of mantle convection hypothesis. The upwelling of hot rock material below an oceanic ridge increases the heat flow around the ridge. The upwelled material spreading sideways cools down, solidifies and sinks in the subduction zone. The cool subducting plate acts as an absorber of heat from the mantle, thus accounting for the lower heat flow values adjacent to the trench region. Deeper in the subduction zone, frictional and conductive heating are sufficient to melt part of the subducting plate, thereby increasing the heat flow behind the arc.

Helium data in terrestrial samples

Keeping the above tectonic model of the earth in mind, let us now look at the data of helium measurements in various terrestrial samples. As mentioned earlier, the first discovery of ^{3}He enrichment in water samples from the Pacific Ocean led H. Craig and associates to speculate the release of primordial helium into oceanic rises where new crust is being formed. Subsequently, similar helium enrichment was observed in the Atlantic Ocean as well. In 1975, it was shown that the maximum ^{3}He enrichment in Pacific waters was found on and adjacent to the crest of the East Pacific Rise where a 32 per cent anomaly in the ^{3}He/^{4}He ratio was observed. The same year, it was also shown that helium trapped in chilled glassy rims of basalt pillows on the East Pacific Rise has a ^{3}He/^{4}He ratio ten times the atmospheric ratio of 1.4 x 10^{-6}. Samples from the Lau Basin, an area of recent crust formation at the western margin of the Pacific plate, also showed a ten-fold ^{3}He/^{4}He ratio enrichment, indicating that similar mantle helium associated with widely separated sea-floor spreading centres.

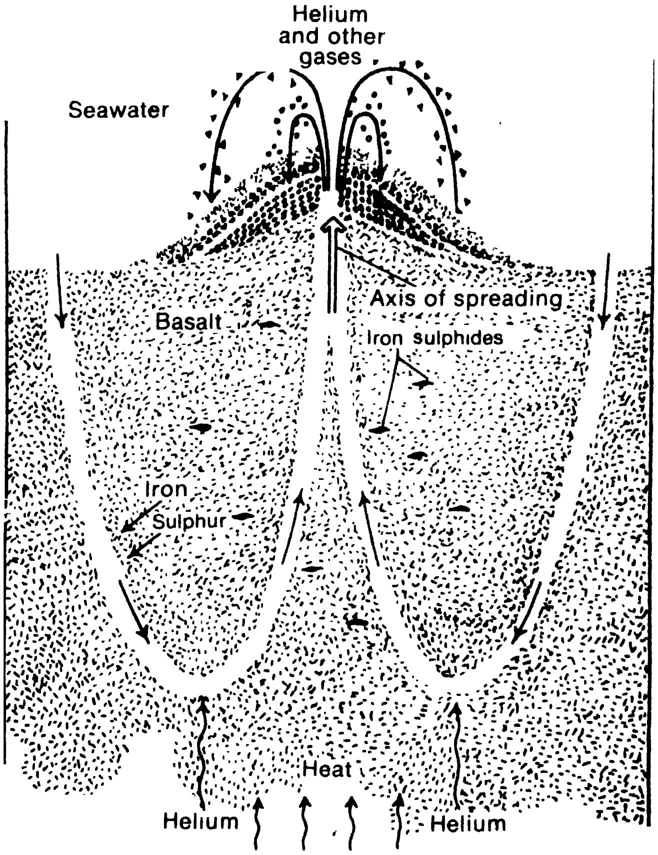
The most spectacular ^{3}He and ^{4}He enrichments in ocean waters occur in Red Sea hot brines. These brines in the axial rift of the Red Sea exhibit super-saturation relative to the atmospheric solubility equilibrium of factor 3,200 for ^{3}He and 370 for ^{4}He, with a mean ^{3}He/^{4}He ratio of 1.21 x 10^{-5} similar to that in glassy basalts. The salt enrichment in these brines comes from evaporites encountered by downward percolation of sea water. If the helium in these brines is derived by the dissolution of evaporites as indicated by the salt enrichment, the ^{3}He/^{4}He ratio would be $\sim 10^{-8}$ (that is, radiogenic). Since the observed value is about 10^{-5}, the helium in these brines is clearly mantle-stripped (see Table 1) from basalts by circulating sea water in an oceanic geothermal system.

The discovery of such spectacular enrichments in He in these oceanic brines led immediately to the application of helium isotopes to the problem of detecting and establishing the existence of hydrothermal sea water circulation as a normal feature of newly created lithosphere on mid-oceanic rises. In 1977, helium isotopic enrichment was further observed in sea water samples from near the Galapagos Rift in association with temperature spikes. The existence of significant hydrothermal circulation with emission of heated water was, therefore, clearly established (Fig. 3).

From these studies, a rather consistent model for the flux of volatiles from the mantle to the ocean and atmosphere has emerged. Water and gases are brought up into the oceanic crust in basaltic melts rising along the spreading centres on mid-ocean ridges. As the lava cools, the newly created crust is invaded by sea water through cracks and fissures, and a *sea water hydrothermal circulation* is set up(Fig. 3).Helium and other gases are stripped from the basalt by circulating sea water and transferred to the ocean by plumes of hot water issuing from basalts. Associated with primordial ^{3}He component trapped in ocean-ridge tholeiites (a type of basaltic rock) are several other components with non-atmospheric isotopic signatures.

Fig. 3 A model of sea water hydrothermal circulation. Water enters the fractured basalt of the oceanic crust near a spreading centre and penetrates to a depth of several kilometres. High temperatures in the zone of magma injection along the spreading centre heats up the water. Thermal convection then drives water back up to the sea-floor where it is discharged through plumes. The heated water extracts a number of elements, including helium, from the basalt

(From "The origin of metal deposits in the oceanic lithosphere", by E. Bonatti. Copyright © 1978 by Scientific American Inc. All rights reserved)



Perhaps the most curious aspect of the helium isotope data from tholeiite glasses is the striking uniformity of ^{3}He/^{4}He ratio in glasses in which absolute He concentration varies by at least a factor of 50. Such uniformity in the ratio of primordial component (^{3}He) to a presumably radiogenic (^{4}He) component implies a very high degree of homogeneity in ^{3}He, U and Th, over long times and in large volumes of the mantle. Another possible explanation of the uniform ^{3}He/^{4}He ratio, however, is that most of the mantle ^{4}He is actually primordial rather than radiogenic. This possibility requires an early and fairly complete removal of U and Th from a major part of the mantle and causes obvious difficulties in understanding the K/U and ^{40}Ar/^{36}Ar ratio in mantle and crustal material through time.

In summary, we know that there really are primordial rare gases in the mantle which continue to be exsolved to the crust, ocean and atmosphere and we have at least a working idea of how these gases get from the mantle into the ocean.

Another mode by which volatiles are transported from the mantle is by volcanic activity in areas associated with convergent plate boundaries as, for example, along island arcs and continental margin orogenic provinces. In the Kurile and Kamchatka regions of the Soviet Union, ^{3}He/^{4}He ratios 5.4 to 6.3 times higher than the atmospheric ratio have been found in hot spring gases. High ^{3}He/^{4}He ratios have also been observed in volcanic gases from the Hakone province of Japan, volcanic islands of the Mariana Island arc and Mt. Lassen in the US.

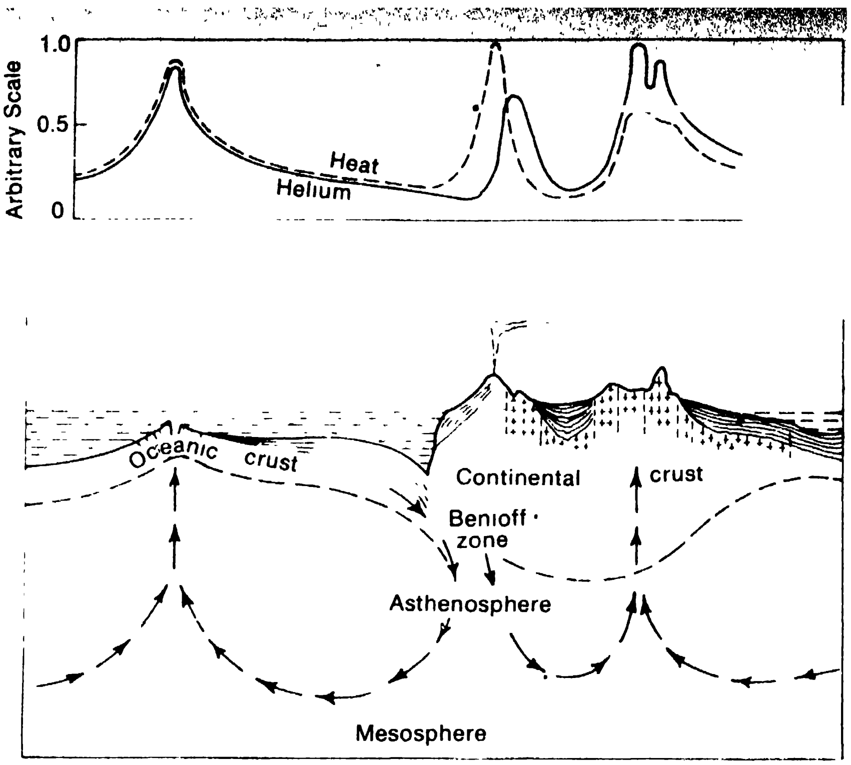


Fig. 4 A regional model of the earth incorporating the plate tectonics, heat flow and a limited number of helium measurements. It is speculated that a high heat flow is correlated with high helium anomaly as along the mid-oceanic ridges and over the hot spots, that is, along the rising arm of mantle convection currents. The subduction zones where convection currents sink, may be characterised by a low heat flow and helium anomalies. Frictional and conductive heating may cause partial melting of the subducting plate and the release of helium trapped in the rock, resulting in a high heat flow and helium anomaly towards the landward side of island arcs

The helium model

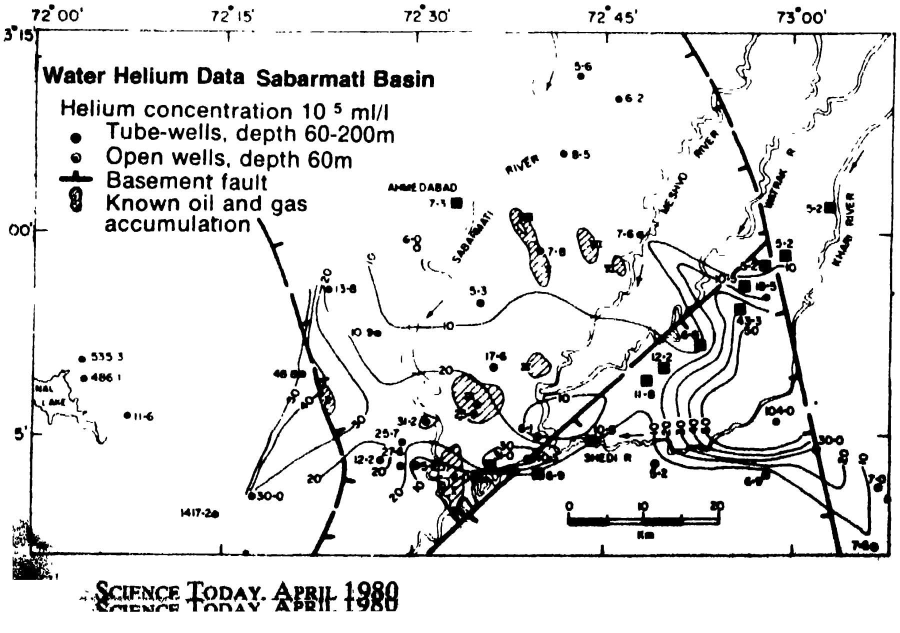
Combining, (i) the tectonic model of the earth as described earlier, (ii) the information provided by surface heat flow measurements, and (iii) the helium measurements along plate margins, it is possible to draw a speculative model as shown in Fig. 4.

Yet another mode by which volatiles are transported from the mantle is by volcanic activity in areas not associated with plate margins. The clearest example of primordial gases far from any plate boundary is given by the very high ^{3}He/^{4}He ratio (15 times the atmospheric ratio) in the Kilauea volcano in the Pacific Ocean. At the Yellowstone National Park, USA, also an observed high ^{3}He/^{4}He ratio indicates a mantle component. These regions are also known to have a high heat flow and are called "hot spots". A variety of geophysical evidence points to the existence of molten magma at shallower depths beneath these 'hot spots'. It has also been speculated that some of these 'hot spots' may represent the rising arm of mantle convection currents. Most of the known 'hot spots' are close to divergent plate boundaries but some are definitely away from plate margins. Arguments have been put forward to link these hot spots with the driving mechanism of plate motion. It is assumed that 'hot spots' are surface expressions of deep mantle plumes. The rising material spreads out in the asthenosphere, producing stresses on plate bottoms. The existing data, however, do not enable us to prefer any one of the various theories to account for the plate motions.

So far we have discussed helium observations made along the plate margins and over volcanic regions. To complete the picture, let us look at the continental helium data. As the solubility of helium is high (~1 per cent) in water, omnipresent groundwaters offer a convenient means for studying the generation and 'migration of helium in the near-surface regions of the earth over continental areas.

During the last few years, Soviet

Fig. 5 Map shows helium concentration in the Sabarmati basin, Gujarat. The helium field is seen to exhibit a high degree of variability which is not yet understood



scientists, particularly Prof. Eremeev of the Moscow State University, have studied the areal distribution of helium in groundwater samples and have drawn regional helium spectra. Similar studies have also been done by the authors in some parts of India (Fig. 5). It is seen that helium concentration in groundwater varies by more than three orders of magnitude. In general, it is also noticed that helium data in groundwaters do not follow any systematic pattern. Some wells singularly show abnormally high helium concentrations. It has been shown that the helium concentration in groundwaters of the Sabarmati basin in Gujarat does not bear any relationship to the radiocarbon age of groundwater. Local variations, in the U/Th content of the aquifers, of the order required to explain the range of variation in helium concentration are also not indicated. On the other hand, a weak inverse correlation of the anomalous helium field with the square of the depth to the basaltic basement is indicated. Similar results have earlier been obtained by Soviet scientists from the Kazakhstan region where the helium field is shown to correlate well with the fault structure in the deeper (over 15 to 20 km) layers of the crust. Unfortunately, data of ^{3}He/^{4}He ratio in the total helium for these regions are not yet available. Some questions, however, arise. Do the deep fault zones, because of their higher permeability, act as feeder channels for helium from the asthenosphere, or do helium anomalies around deep fault zones arise due to the setting up of a hydrothermal circulation and stripping of helium from the rocks as near the oceanic rises? Or is there an abnormal radioactive mineral accumulation along fault zones? In the last case, the ^{3}He/^{4}He ratio would be low ($\sim 10^{-8}$).

Another interesting speculation concerns the possible correlation of a high helium anomaly, in the intraplate regions not associated with hot spots, with intraplate seismicity. We have already seen that high helium anomalies are observed along the existing plate margins and intraplate regions associated with hot spots. Recently L.R. Sykes of the Lamont-Doherty Geological Observatory, USA, has suggested that seismicity in the intraplate regions may be associated with the old plate margins representing zones of weakness. Then a question arises: are the deep-seated fault zones, which are seen to correlate with high helium anomalies, in some way related to the old plate margins? If so, it may be possible to study the deep structure of the continents and the intraplate regions through the helium probe.

In conclusion, it is clear that the study of terrestrial helium has provided a new and potentially powerful tool to the understanding of the evolution of our planet through geologic times. Several questions, however, remain unanswered.

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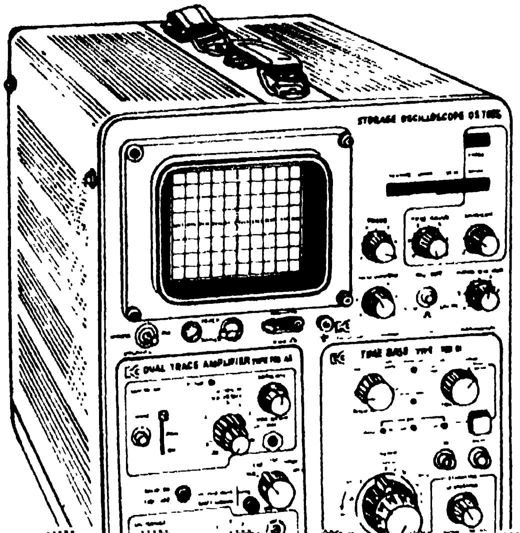

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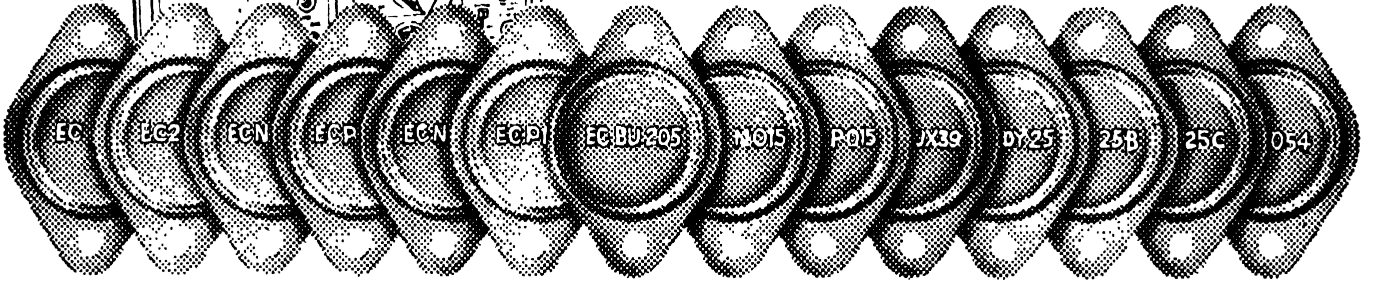

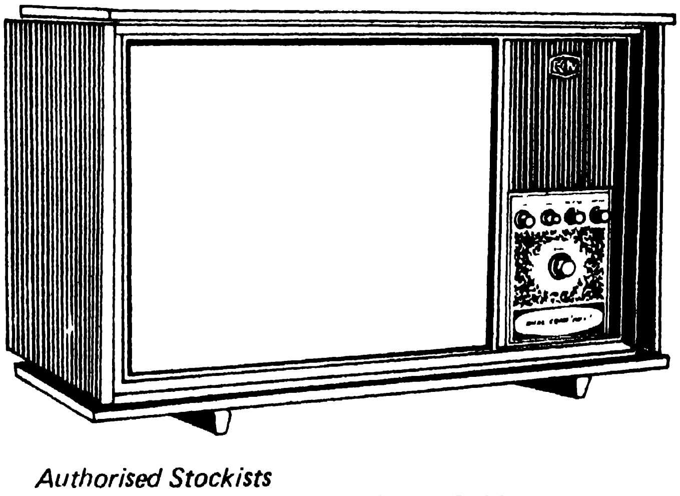

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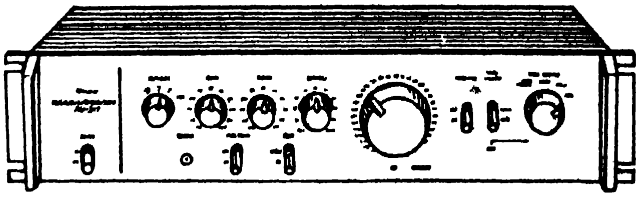

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A unique gamma ray shower

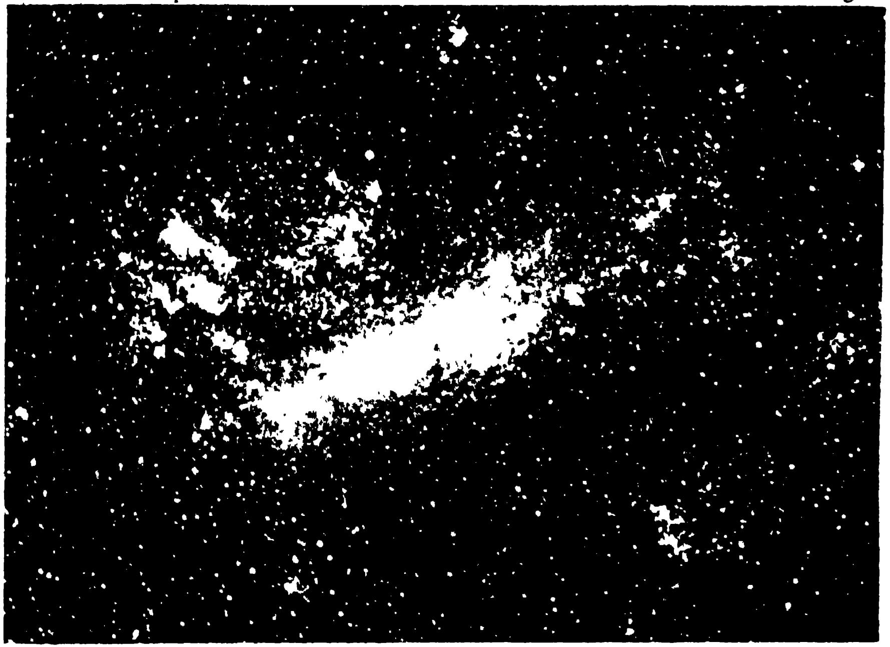
GAMMA RAY bursts (SCIENCE TODAY, June 1979, p.34) originate somewhere in space and travel through space as showers lasting some tens of seconds. Many such showers were observed near the earth and in the solar system by satellites. The energy of these bursts ranges from a thousand to million times the energy given off by the sun in a second.

Several space ships and satellites situated at different regions of the solar system were used to locate the region of the sky where the gamma ray bursts come from by using the triangulation procedure. Triangulation is a method of calculating the distance of an object by observations from two different points at a known distance. The further the object is located the greater should be the distance between the two known points.

In the case of the gamma ray bursts, the direction from which the burst arrives has not yet been determined, but the times of arrival of the burst at two observation points, say A & B, have been noted. If C is the location of the source, the difference in time, multiplied by the velocity of light, gives the difference between CA and CB. Now C can turn out to be anywhere on a circle in the sky. If, however, there are more than two observers, then a series of bands can be drawn, using pairs of detectors. The intersection of these bands gives the location of the source of the burst.

So far it has not been possible to accurately pinpoint the location of objects responsible for these gamma ray showers.

A unique gamma ray shower was observed on 5 March 1979 by nine Soviet and American satellites and spacecraft (*Nature* **282** 587 and *Science* **205** 119). The burst is unique in several respects: (1) it is the most intense burst observed so far, (2) it shows a periodicity, and (3) its location is accurately determined since it was observed by a large number of satellites. Indeed there *is* an optical object at the location. The optical object is a remnant of an explosion of a star (supernova remnant) in our neighbouring galaxy, the Large Magellanic Cloud, which is about 15,000 light years away. The Soviet satellites Venera 11 and Venera 12 found the gamma ray burst to have a periodicity of 8.1 seconds. They also observed that gamma rays were more intense at an energy of around 430 ke V than at other energies. They observed gamma ray bursts from the same location thrice again in 1979 but none of them were as intense as the 5 March shower.



The large magellanic cloud, the galaxy nearest to our own

A better understanding of the object is possible if radiation at other wavelengths is observed from the object. Therefore the powerful Einstein observatory, an American satellite carrying X-ray detecting instruments, was turned to look at the source of the gamma ray burst (*Nature* 282 589) but no X-rays were observed.

Do these gamma ray showers originate in the supernova remnant in the Large Magellanic Cloud? If they do, the brilliance of the 5 March event should be an unbelievable 100 billion times that of the sun in order to give the observed intensity near the earth. We know of no way to pack so much energy in gamma ray photons in a short span of a few tens of seconds. Or, could it be that the gamma ray shower originated in our own galaxy and its location just happened to superimpose the supernova remnant in the Large Magellanic Cloud? Astrophysicists believe this to be the case. This brings the source closer to us (a few hundred light years) and its brilliance to a manageable million times that of the sun. We know of some other sources which give out energy of that order though at other photon energies. Also, the excess gamma rays observed at 430 keV is believed to be due to annihilation of positrons with electrons. The energy of 430 ke V is slightly different from the energy of photons given off during the positron-electron annihilation and this shift is believed to be due to the intense gravitational field (gravitational redshift) of a neutron star of mass approximately equal to that of the sun.

Scientists are analysing in detail the data of 5 March 1979 burst and looking for clues to explain these mysterious gamma ray showers. Also, they are looking for more bursts from the same source located towards the supernova remnant in the Large Magellanic Cloud. Meanwhile, theoretical astrophysicists are racking their brains to come up with a model to reproduce all the features of the event.

KRISHNA M.V. APPARAO

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Intestinal B_{12} synthesis by some vegetarians?

VITAMIN B_{12}, the most potent of the known vitamins (on a weight basis), is essential for normal formation of the cellular elements of the blood (hemotopoiesis) and the maintenance of the nerve myelin sheath. The original and sole source of this compound in nature appears to be vitamin-synthesising microorganisms. Ruminants, which consume a large amount of forage inedible to man, operate an internal fermenter (see SCIENCE TODAY, February 1980, p.67) within their alimentary tract where microbial synthesis of vitamin B_{12} occurs providing a source of the vitamin to these animals. Lamb and beef liver are rich sources of this vitamin. Muscle meats,. some sea foods (clams and oysters which siphon B_{12} synthesising organisms from the sea) and egg yolk are moderately rich sources. Adequate quantities are found in milk and dairy products. But it is absent in plants, which do not need it.

In man, bacterial synthesis of the vitamin occurs in the large bowel, which cannot absorb it. While a daily intake of 0.1 μg of it would be sufficient to produce a hematological response in B_{12} deficiency, normal subjects as well as deficient patients (pernicious anemia) excrete daily as much as about 5 μg of the vitamin in the faeces. Less fastidious rabbits are known to consume their own faeces at night to obtain their vitamin B_{12} supply (coprophagy).

It has perplexed workers in the field how some pure vegetarians maintain their vitamin B_{12} supply. An answer has been attempted in a recent paper by M.J. Albert, V.I. Mathan and S.J. Baker (*Nature* **283** 781) of the Christian Medical College, Vellore. They have obtained bacteria by aspiration from the jejunum and ileum (which are the middle and last portions of the small intestine) of healthy south Indian control subjects (the exact dietary habits have not been defined) and patients with tropical sprue where there is an impaired absorption of food, water and minerals by the small intestine. From such aspirates they have isolated numerous strains of aerobic and anaerobic organisms. These have been monitored for their ability to produce vitamin B_{12} like compounds or their analogue by differential microbiological assays. *Pseudomonas* and *Klebsiella* species were found to synthesise sufficient amounts of biologically active vitamin B_{12} compounds which could bind with the abundant levels of intrinsic factor (a protein produced by the stomach and, if absorbed, could contribute adequately to the vitamin B_{12} intake of the individual). Lack of the intrinsic factor is believed to be a cause of pernicious anemia.

The authors, however, admit that the role of the intraluminal bacteria in human vitamin B_{12} metabolism is quite complex. Subjects with bacterial overgrowth in the small intestine (stagnant bowel syndrome), a condition frequently associated with vitamin B_{12} malabsoprtion, often respond to a broad spectrum antibiotics. This would suggest that the bacterial overgrowth possibly promotes production of toxins, large amounts of vitamin B_{12} analogues or alterations in the intrinsic factor of B_{12} complexes which eventually affect vitamin B_{12} absorption adversely.

An explanation is offered as to why vegetarian Indians are less susceptible to B_{12} deficiency than their counterparts (eating similar diets) who are immigrants in England. The latter are marked by the absence or diminished bacterial flora characteristic of most subjects living in the 'protected environment' of western countries. They lose their endogenous source of vitamin B_{12}. While the point is not elaborated further, it is possible that the greater availability of processed foods involving thermal treatments (canning), additions of chemical preservatives, antioxidants and other additives (instead of condiments and spices) to extend shelf life and acceptability, may be factors contributing to the diminished bacterial flora of the small bowel among those Indians living in western countries.

J.M. NOROHNA

Dr. Norohna heads the "Metabolism of Vitamins" Group in the Biochemistry and Food Technology Division, BARC, Bombay.

Neoplastic transformation in cell cultures

IN understanding the mechanism of carcinogenesis or development of any sort of malignancy, the isolated cell system offers the advantage of overcoming hormonal and other influences that are operative in the whole mammalian organism. It also helps in studying the effects of potential cancer-inducing agents on specified target cells without the normal limitations imposed by tissue barriers.

Oncogenesis or the process of tumour formation in culture was first achieved with virus as the inducing agent and was followed by the finding that chemicals and radiation are also capable of malignant transformation of cells *in vitro*. Extensive *in vitro* studies in the last decade have helped reveal that malignant transformation of cells is a multistep development. A number of biological markers have been suggested as indicators of transformation, but the ability to proliferate in semi-solid media and induction of tumours in the host are the commonly accepted criteria for all cell types. There has been a revived interest in the subject as cell transformation is considered as the most relevant and reliable short-term test for assessment of carcinogenicity.

The evaluation of carcinogenic risk from nuclear radiations has been a subject of considerable scientific controversy. The experimental data on the induction of malignancy are based on high doses; attempts to find out the effect of low doses are still beset with many problems. Using the *in vitro* mammalian cell transformation technique, Carmia Borek and collaborators at Columbia University (USA), have made extensive investigations aimed at a more precise understanding of the carcinogenic potential of low doses of X-rays. Very recently, C. Borek (*Nature* **283** 776) has successfully achieved neoplastic transformation or an aberrant new growth of human diploid cells by X-irradiation. This achievement must be viewed in the light that normal human diploid cells are highly resistant to transformation. There have been only two reports of their successful *in vitro* transformation, and in both the cases by some chemical carcinogens. In C. Borek's study, the skin fibroblast strain KD cells, originally derived from a human skin biopsy, were synchronised and irradiated. The irradiated cells were checked for transformed foci 60-80 days later, and when seeded in semi-solid agar could proliferate to form colonies.

Borek's success in transforming human diploid cells by X-rays is all the more significant because it opens up possibilities of a more precise definition of the dose-response relationship at low doses of radiation. With the availability of such data, we can estimate more precisely the cancer risks in human populations exposed to low-dose radiation.

A.S. AIYAR

Dr. Aiyar is the head, Biochemical Toxicology Section, Biochemistry & Food Technology Division, BARC, Bombay.

Brain drain...

(Contd. from p. 10)

where in banking or commerce?

BARC, of course, is not the only example of a scientific organisation where working scientists have been grossly maltreated and demoralised. Everyone is aware of the happenings at the ICAR, ICMR and CSIR which have faced high-level inquiries at one time or the other. At the Defence Science Laboratories (DSL), things are equally bad, if not worse, and are progressively worsening. These laboratories also do not depend on industry for utilisation of their R and D work but scientists are facing decline in their career opportunities and seniority. Recently, the practice of making seniority lists was discontinued. A scientist had to go to the Delhi High Court for restoring this practice. The High Court had to remind the science managers there that it was the right of every employee to have a reasonable idea of his chances of promotion and that seniority lists should therefore be drawn up. Another recent blow against the scientists at DSL has been the reservation of one-third of the R and D posts for military personnel. Not only does this deprive the civilian scientists of job opportunities and promotion avenues, but it also creates an unhealthy situation in which certain scientists in the same organisation are far more favoured than others of equivalent ranks. The implication is that a purely scientific career is inferior to a military career.

To summarise, the present flight of bright students from science courses is not entirely due to our import policy. Those who are genuinely concerned about the disinclination of our bright students to join science courses must do soul-searching about the way Indian science has been managed and how the younger and the brighter scientists have been treated. Scientists must put their house in order to make it attractive to bright youngsters. This will involve recognition of past mistakes and reversal of at least those attitudes and policies which have forced so many of our brighter scientists to leave Indian laboratories.

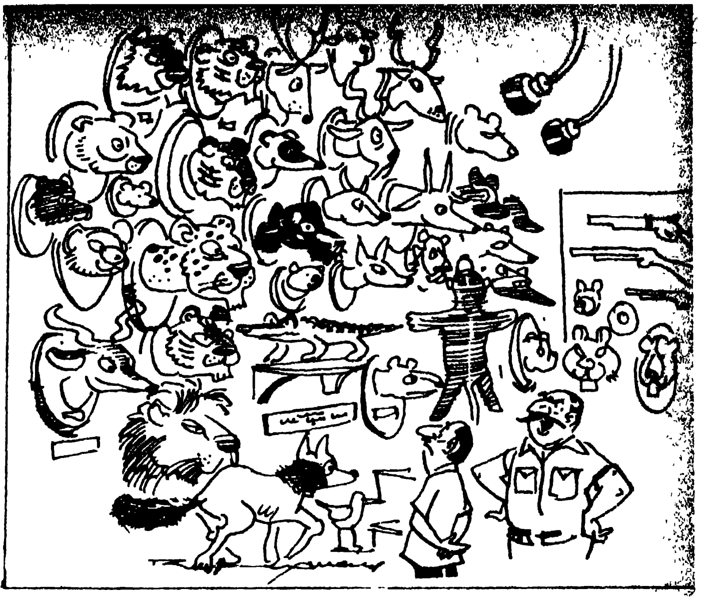
M.P. SANKARAN

Mr. Sankaran is honorary secretary of the Bhabha Atomic Research Centre Officers' Association, Bombay.

This World of Science!

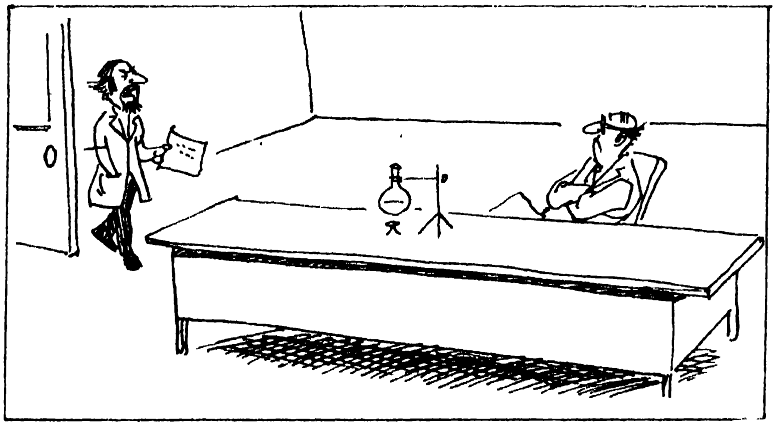
by R.K. Laxman

"How to find inner peace? How am I to know—I too am an American."



"I am sorry for them. I understand they are steadily decreasing in number."

"There is a further cut in the research funds, professor, because we haven't shown much by way of results"



"Are you sure you have learnt the science of bonsai—how to cut the roots, what to tie up and so on?"

... and of Scientists!

CANON JOSEPH SETTLE, professor of astronomy at Rome, wrote an essay showing the correctness of the Copernican theory. But since the edict condemning the latter was still in force, he was refused the licence for its publication. Since he persisted, the Congregation of the Holy Office met on 16 August 1820 to consider the case and, as a result, the Roman Church decreed that whereas until that day the Sun had gone round the Earth, later the Earth went round the Sun—'by permission of the Congregation of the Holy Office', of course.

* *

DURING the entire Reign of Terror, the French astronomer M. Lalande confined himself to the study of his science, not moving out at all. When the Robespierrean fury subsided and he came out, someone asked him how he managed to escape the fate of so many scientists.

Lalande replied: "I must thank my stars."

WHAT do scientists understand by 'Nature'? Here are some answers given by different scientists:

Galileo: "The real world is a world of material bodies moving in space and time and ultimately reducible to mathematical expression."

Descartes (foreshadowing Eddington): "The world is mathematical in structure and nature is completely mechanistic in its operations ..... the reduction of material phenomena taking place because of a causative sequence."

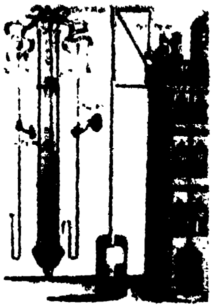
Boyle: "The alphabet in which God wrote the world was in terms of mathematics and mechanics."

Newton: "All changes in nature are the outcome of atomic motion."

Leibnitz: It is "an insult to God to believe that He could not have so designed a world that it would proceed on its orderly way without His constant direction and supervision."

S. N. MUNSHI

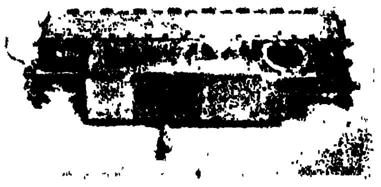
Galileo's drawings of moon phases



Boyle's experiment on "the spring of the life"

Newton's demonstration of the unstable inclination of the Moon's orbit

Leibnitz's calculating machine



LOW-COST HOUSING

TECHNOLOGY OR ACTION?

Unnayan

S.N. Kulkarni

THE SIGHT is all too familiar in our cities and towns—clusters and vast colonies of cramped, ramshackle huts, perched as if on a cesspool, dominate part of the landscape, filling every available plot of land. For the people living in these *jhuggis, bustees* or *zopadpattis,* these slums are their homes, the only possible place where they can live in the city; for the well-fed and well-housed person, they are an unwanted eyesore that he would like to see removed beyond the limits of the city; and for the architect, town planner or civic official, they are part of what he would refer to as the housing problem.

If by the housing problem we mean cramped, insanitary dwellings where people are forced to live, then the housing problem is perhaps as old as human history. Yet it is only since the beginning of the industrial revolution that the housing problem or the housing shortage became acute. This is because, with industrialisation and the consequent migration of large populations into towns and cities, there is, in the words of a nineteenth century observer, a "peculiar intensification of the bad housing conditions of the workers—a colossal increase in rents, still greater congestion in the separate houses and for some the impossibility of finding a place to live in at all".

In India, the serious nature of the housing shortage has been recognised ever since independence. This has led to the establishment of various organisations such as the National Buildings Organisation (NBO), the Central Building Research Institute (CBRI), the Housing and Urban Development Corporation Ltd (HUDCO) and to governmental sponsorship of various housing schemes for industrial workers and the urban and rural poor. What has been the result so far?

Till the end of December 1978, the expenditure on housing under various state-sponsored housing schemes was Rs. 2,645 crores. This included the cost of 793,334 houses, most of them for the lower income group (LIG) (earning less than Rs. 600 a month) and for the economically weaker sections (EWS) (earning less than Rs. 350 a month). The houses built were either rented out or sold on hire-purchase. In most of the schemes, some sort of governmental subsidy was involved: either a direct subsidy

Illustrations Nana Shivalkar

DOES EVERYONE
HAVE THE RIGHT
TO DEMAND
DECENT HOUSING ?

of up to 50 per cent of the cost of construction and land development and/or a subsidy by charging interest far below market rates. Besides this, over seven million house sites were given to the rural landless. Though the success of these governmental schemes has not been fully evaluated, a common observation is that the houses built under these schemes rarely go to people for whom they were intended (see p.28).

J.F.C. Turner, an authority on housing in the Third World, cites the reason for this: "Interpretations and forecasts of effective housing demand fail so frequently mainly because it is wrongly supposed that 'people *will* invest a given proportion of their income that bank or government agency people assume that they *can* invest. For the lowest income group, the amount they can spend on housing is negligible or even negative, after feeding and clothing and travel to work." But because of the general housing shortage, government sponsored schemes find ready tenants or buyers, though the people who end up living in such houses are rarely the people for whom these houses were built.

How do public housing efforts compare with the demand for houses? Though data on the housing stock is incomplete and estimates of the housing shortage vary according to the minimum housing standard acceptable, the housing shortage in March 1979 was estimated by the NBO to be 4.9 million units in urban areas and 14.8 million units in rural areas. To this must be added the additional requirement due to the increase in population and to replace the housing stock that becomes unusable every year. The Planning Commission has estimated in the Draft Five Year Plan (1978-83) that if the housing shortage is to be eliminated within 20 years, 4.5 million housing units need to be built each year—1.2 million in urban areas and 3.3 million in rural areas. It adds: "Assuming an average cost of Rs. 15,000 per unit in urban areas and Rs. 3,000 in rural areas, the total annual investment in housing works out to Rs. 2,790 crores." Against this, the average annual expenditure in both the public and private sector during the Fifth Plan (1974-78) is expected to be around Rs. 950 crores. Even this figure is misleading because the private sector (which invested Rs. 3,636 crores in housing during the Fifth Plan compared to an investment of Rs. 1,044 crores in the public sector) builds houses mainly for the rich and middle-income groups.

Isn't it somehow possible to lower the cost of building a house by using new materials and new methods of construction? True, many innovations in construction technology have been made in recent years. In India, the CBRI and other institutes have evolved ways in which to reduce the cost of a house considerably (see p.34). By designing houses with lower standards of finish and by making suitable changes in house elements like doors, windows, roofs, superstructure and flooring, further economies are possible. Recently, the NBO publicised a one-room house that could be built for less than Rs. 1,500 (see p.35).

Science Education Group

But a number of problems remain. For one thing, most of these innovations remain at the design or experimental stage. Because of a lack of proper co-ordination, the building trade and government housing authorities have not begun to use these innovations extensively. And the changing concepts of acceptable standards are not reflected in various bye-laws and building regulations that still determine what is acceptable to local authorities that sanction building plans and authorise their construction.

Even if these innovations were widely implemented, the savings would be around 20 to 30 per cent. This would still not cover the gap in investment. Other approaches must be found. One could, of course, argue that housing is an economic activity with a high employment-generating potential. One estimate (for 1972) is that every one lakh rupees worth of construction generates 2,765 man-days of skilled, and 5,450 man-days of unskilled employment at the work-site, apart from the indirect employment in ancillary industries such as brick manufacture, transport, etc. These are some of the general aspects.

Besides this, one can question the priority given to housing in our plans. Does everyone have the right to demand decent housing along with food and employment, or are these to be settled by laws of supply and demand? Every socialist country has undertaken massive housing programmes, determining rent as percentage (normally between four and eight per cent) of family income rather than as a desirable rate of return on investment. Since our priorities are different, our planners believe that such an investment in housing "is inconsistent with the likely resource availability if other priority investment is not to suffer".

Yet, because the shortage of housing for the urban and rural poor has reached crisis proportions, some solution must be found. Is any solution possible? P.M. Apte reflects a recent trend of thought when he says (see p.28) that we have to spend "more on the creation of an infrastructure that can act as an incentive to promote investment in low-income housing. All we have to do is to give (the urban poor) a place where they can produce a shelter that will still be a hut, but where all the public amenities that our civilisation and economy can afford to give at present, are available". What this point of view emphasises is that housing, besides including the house, necessarily concerns itself with the provision of water, drainage, electricity, roads, and space for recreation. In other words, the infrastructure is as important as the house.

This promotion of self-help housing has begun to influence official policy. The Draft Plan (1978-83) has provided Rs. 500 crores for eight million house-sites for landless rural workers and Rs. 446 crores for urban slum improvement programmes covering 1.5 million families. Meanwhile, major slum improvement programmes have been proposed in some cities (see p.42). Though these schemes aim at providing some of the basic civic amenities like latrines, water taps, drains and paved roads (while the huts are built by the residents themselves), they are often not fully implemented. At the same time, the slum-dwellers (who are essentially squatting on land they do not own) are shifted, whenever possible, to sites outside the city to land over which they once again have no legal right (see p.44).

The advocates of sites-and-services insist that ownership or a secure tenure of land is central to the success of any scheme where people are expected to build their own homes. As Shirish Patel points out (p.40): "Investment is related to risk. If a *zopadi* dweller feels he is likely to be evicted at any moment, he will spend as little as possible on his shelter... If, on the other hand, he is given reasonable security of tenure he will not only try to build a better dwelling, but will continue to improve on it over the years."

The late Charles Abrams, who had extensively studied the housing problem in the Third World, was quite categorical: "To look upon all squatters, or even the majority of them, as lawbreakers, is to misjudge the problem. Had land been made available to him, the squatter would not have appropriated it... Ownership is almost always a precondition to successful self-help operations anywhere."

There is another factor to be considered. Each individual hut in a city slum represents an investment in labour and materials—an investment that gradually grows each year. The residents have built up personal ties within the community and normally live fairly close to their place of employment. To shift these settlements to plots on the outskirts of a city would not only mean destruction of part of the housing stock but would add considerably to the cost of travel to and from work.

Any realistic sites-and-services scheme would, therefore, have to sell or lease, at reasonable rates, to the squatters the very land on which their huts stand, or if this is not possible then to shift them to a nearby site. This would imply a radical change in the perspective of our policy makers and an ability to resist pressures from slumlords and property speculators.

YOGI AGGARWAL

HOUSING URBAN POOR

Available resources can best be used by spending less on the direct production of houses and more on the creation of an infrastructure

P. M. Apte

It has been said that world history is city history. All over the world, cities exert an influence on national life which is quite out of proportion with their population. This is true of Indian cities also.

Yet, our towns and cities are beset with a host of problems. Adequate housing is one of the more crucial of these. Can we formulate a realistic housing policy that takes into account the prevailing conditions in our cities and the resources at our disposal? Going by present population trends, the situation is not very hopeful.

Of the total population of 548 million in 1971, 108 million (or 19.9 per cent) lived in urban areas. Eight metropolitan cities accounted for 25.3 million of this urban population. Besides, towns with populations over 100,000 increased in number from 81 in 1951 to 142 in 1971. Similarly, the number of towns with populations between 50,000 and 100,000 had increased from 102 in 1951 to 198 in 1971.

The total population of India is expected to rise to 668 million in 1981, 801 million in 1991 and approximately 945 million in the year 2001. According to the projections made by the Registrar General of India, current trends of urban and rural growth will mean a 30:70 ratio of urban to rural population by the year 2001. Thus, an additional 221 million people will be added to the rural population and 175 million to the urban population in 30 years from 1971. This is likely to further accentuate densities in metropolitan cities.

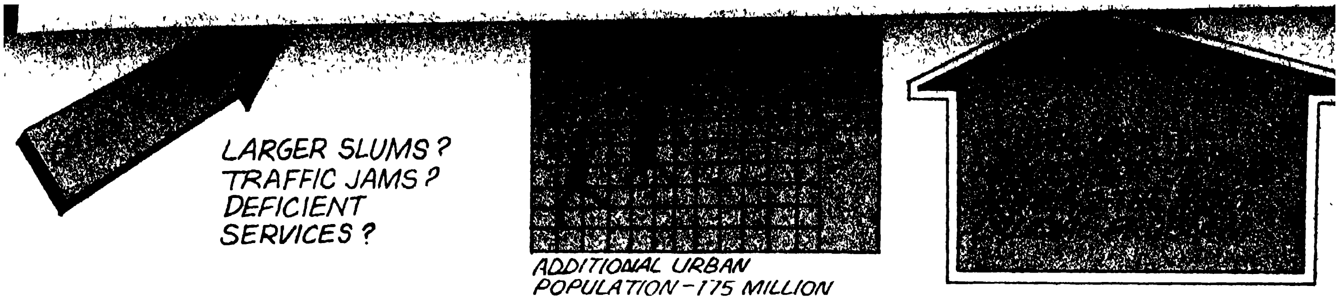
Thus, the present metropolitan cities are expected to get even more crowded. The result could be larger slums, additional squatters, increased traffic problems, decreased efficiency of services and accelerated growth of social evils. If we are to avoid the problems resulting from excessively concentrated urbanisation, a beginning has to be made by taking positive steps for the dispersal of population and activity through a network of well-conceived growth centres as an integral part of balanced regional plans of larger cities. This would require a hierarchy of townships, with particular emphasis on the creation of smaller but viable growth centres based on a careful analysis of the developmental potential or capacity of each area and region.

Besides developing new growth centres, the existing urban land also requires to be put to optimum use. According to a Town and Country Planning Organisation Survey in 1966, 58.5 per cent of the urban land was developed and 41.5 per cent undeveloped. Cities with populations over 500,000 had the highest percentage (74 per cent) of developed land. Also, the average gross density, on the basis of 120 million people living in urban areas with a total area of 38,000 square km, works out to 32 people per hectare. Since a gross density of 75 people per hectare is quite acceptable, many of our urban areas should be able to accommodate more than twice their present population without any increase in area. However, this will not be possible in all cities, since in many cities the densities are already very high.

Given the above factors, the main objectives of a national urban land policy should be: (i) to make adequate land area available at reasonable prices to both public authorities and individuals; (ii) to prevent concentration of land ownership in a few private hands; and (iii) to ensure that a substantial part of unearned increments in urban land and property values is mopped up to restrict speculation and to achieve economic and social equity.

In order to achieve this, compulsory acquisition of land remains the most crucial problem. The Twenty-fifth Constitutional Amendment, 1971, and the Urban Land (Ceiling and Regulation) Act (1976) now make this possible by giving Parliament greater power to fix compensation in the case of land acquired for public purposes. It is necessary that the powers given to governmental agencies by these laws be effectively used while framing an integrated policy for urban land use, development and disposal of land. This has not been done so far, as is indicated in the latest report of the Ministry of Works and Housing. Out of the total of about 95,000 hectares of so-called vacant land that would be available to the government, only 384 hectares has been acquired so far.

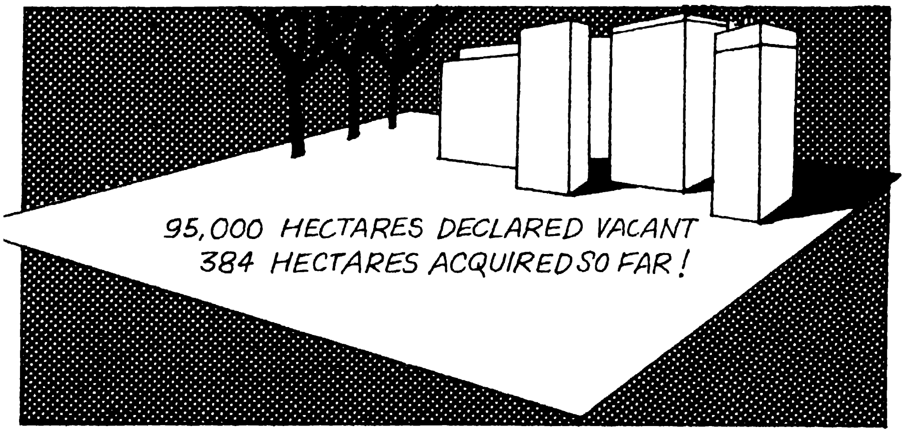
However, it must not be forgotten that land is a resource, and every resource has to be costed at its opportunity cost. Socialisation of a resource does not take away its opportunity


LARGER SLUMS ?
TRAFFIC JAMS ?
DEFICIENT
SERVICES ?
ADDITIONAL URBAN
POPULATION-175 MILLION

cost, but merely eliminates the market mechanism that determines its price. In other words, it can prove costly to society to underutilise urban land.

In the context of housing for the poor, it becomes necessary to reduce the overall opportunity cost of land. This can be achieved through an increase in the effective supply of land. But so long as such measures are not made operational, it would be necessary to improve, and not uproot, the existing squatter settlements on high opportunity cost land. The subsidy, inherent in such welfare measures, should be accepted as the cost of our inability to keep the overall opportunity cost of land at the desired level.

To be effective, the country's housing programme has to be in line with the country's income level. Most of the National Sample Surveys indicate that 75 per cent of our urban households have an income of less than Rs. 350 per month, and another 15 per cent less than Rs. 600 per month. Unless our housing agencies accept the fact that their market is, or should be, this 90 per cent of households below the income level of Rs. 600 per month, and choose to design and produce goods to suit their taste and means, they will continue to serve the well-off sections as they have been doing for the last 30 years.


95,000 HECTARES DECLARED VACANT
384 HECTARES ACQUIRED SO FAR !

Housing policy

The NBO estimates that there is a shortage of 19.7 million dwelling units in India, of which 4.9 million units are in urban areas. The estimates, however, greatly vary with a change in the definition of *kutcha* and *pucca* houses, and while a broad idea of the total housing shortage in the country is available, detailed estimates for various regions and metropolitan areas have not yet been computed. In the absence of such areawise estimates, either by a central agency or by regional agencies, the decisions for investment in housing tend to be taken on extra-economic considerations. For example, many housing agencies invest in a very small number of houses in small towns. The final impact of such houses on the total housing shortage in the region may be negligible. Thus, while on the one hand we despair at the meagre allocation of resources, on the other hand, we spend the available resources such that it has no relevance to the problem.

This is borne out by the latest report of the Ministry of Works and Housing on the role of public housing agencies. Of a total of 793,334 houses built by public housing agencies since independence, only 23.4 per cent have been for families earning less than Rs. 350 a month, and only 41.5 per cent for families earning between Rs. 350 and Rs. 600 per month. The situation is even worse than indicated by these figures if we consider the number of EWS or LIG houses actually occupied by these income groups. J.B. D'Souza, former chairman of HUDCO, points out in a recent article that: "Recent surveys of HUDCO financed houses in north India showed that 73 per cent of EWS houses that cost Rs. 8,600 were in reality occupied by LIG families. LIG and even MIG families occupied 90 per cent of EWS houses that cost Rs. 10,000." Similarly, LIG houses are generally occupied by MIG families.

The situation becomes even more bleak when one considers that public housing agencies account for only 25 per cent of the investment in housing. This is even more so when we consider the growth of the co-operative movement in India. Housing co-operatives have made progress mainly in Gujarat, Maharashtra and Tamil Nadu, and have absorbed a significant proportion of public funds allotted to housing. However, a recent study has indicated that their performance was no better than that of public housing agencies.

This has to be considered in the context that the private sector, which accounts for 75 per cent of the investment in housing, has built houses almost exclusively for the middle-income and higher-income groups. Thus the net effect is that only a tiny portion of the investment in the organised housing sector benefits the poor.

Housing or Infrastructure

Our concepts of housing are, like any other subject, conditioned by our culture, social and economic background, upbringing, habits and vision. What is a necessity for one, could be a luxury for another. It may be claimed that the required minimum housing standard can be defined in terms of biological and anthropometric considerations. Yet, when the question is almost one of survival, what is the degree of importance that we should attach to these considerations? If our resources do not permit the provision of even minimum standards, should we then condemn the people to live at these standards for ever, by building houses that will last for 100 years, or should we think in terms of 15 to 30 years?

Even the existing housing standards are not comprehensive and merely provide guidelines about plinth areas for government housing. For private housing, it is the municipal bye-laws which decide the housing standards. A greater part of our success or failure in solving the problem of housing will depend upon how realistically we fix our standards for housing. Our approach should be to feel content, for the time being at least, with only improving upon the existing conditions rather than fixing idealistic norms which we shall not achieve and ultimately end up by building for a few people and leave the majority in their present sorry state. Obviously, decisions about housing standards cannot be taken at the level of the municipal bye-laws but must form part of a national housing policy.

In the context of our economic conditions, it is difficult to dispute the argument that indirect investment in the development of infrastructure facilities like developed plots, water and sanitation facilities, and cultural and employment centres, may be a more prudent way of investing than the construction of houses. It is in fact possible to do so, particularly for the poorest of the urban households, in order to give them security of tenure and a healthy living environment. For those who are a little better off, we could provide the minimum accommodation—a single room which is renewable and to which additions can be made as and when the occupants can afford them. Obviously, this kind of a concept can be implemented only if organised efforts are made to encourage renewable housing.

We thus have to lay greater emphasis on stretching available resources by spending less on direct production of houses and more on the creation of an infrastructure that can act as an incentive to promote investment in low-income housing. On such developed plots, therefore, the urban poor can build make-shift houses and improve upon them in time if they are assured of good and well-lit roads, potable water and sanitary conditions with open parks, health facilities and most important, security of tenure on the land on which their huts stand. The urge and readiness to build one's own house with materials and techniques within one's reach is already very strong in the large masses of the urban poor. All we have to do is to give them a place where they can use this technique to produce a shelter that will still be a hut, but where all the public amenities that our civilisation and economy can afford to give at present are available.

A tool for generating savings

Housing has so far merely been treated as a social welfare activity rather than an economic activity which has its own income, employment generation and redistribution potential. The investment in the housing and urban development sector has in fact been progressively reduced from the First to the Fifth Five Year Plan from 12 per cent to 1.5 per cent of total plan investment. It is time to examine the significance of investment in housing in relation to other competing sectors.

Isolated studies of housing finance have been made from time to time. The report of the Banking Commission is also available. These studies have suggested certain measures for mobilising resources for housing. But the suggestions have to be supported by empirical studies in the following fields: (i) institutional finance for housing and its relationship to the money market; (ii) the financial implication of incentives to the private sector; (iii) introduction of mortgage loan insurance and the development of a secondary mortgage market to help mobilise additional resources and increase liquidity of housing investment; (iv) the possibility of levying a cess on workers' wages to raise resources for housing, and (v) utilisation of the employees' provident fund for housing or the creation of a separate housing provident fund.

Housing is a part of the infrastructure for urban development. It can also be used as a tool to accelerate or decelerate urban growth. In a large metropolitan city, the need and demand for housing can attract investment in that sector and the pouring investment may lead to further growth. If we can understand this cyclical process then it should be possible to develop new growth centres by co-ordinating investment by existing institutions like the industrial infrastructure corporations and housing agencies so that we create 'reception centres' for the injection of new economic activity.

Though housing may not top the hierarchy of human needs in the Indian context, it is a very strong urge that can provide a great incentive to save. Families at all income levels, if fairly certain of getting a house, can go to great extents to save for it. As about 90 per cent of the urban households belong to the lower-income groups and since most of the public and private housing activity has not been catering to their needs, it is obvious that there has not been sufficient motivation for them to save. If our private and public agencies can tailor their merchandise—a house—to suit the pockets of this large mass of urban poor, it can create a tremendous incentive for savings. The effect of this saving on capital formation and on reducing money in circulation can be very well anticipated, resulting in reduction of inflation and a greater availability of consumer goods.

Mr. Apte was, until recently, Projects Chief at the Housing and Urban Development Corporation (HUDCO), New Delhi. The views expressed in this article are the personal views of the author and do not necessarily represent the official views of HUDCO.

BOMBAY: THE NARROWING OPTIONS

V.K. Phatak

BOMBAY, a city of only 900,000 people in 1901, has now crossed 7.5 million And the population continues to grow at a rate of over four per cent a year. By the turn of the century, it would shoot up to 15 million people.* During the last couple of decades the city has grown beyond its traditional boundaries, and meaningful planning for the city could only be undertaken on a regional basis.

The Bombay Metropolitan Region Development Authority (BMRDA) was set up to plan and develop the metropolitan region of over 4,000 square km. In 1977, the BMRDA formulated a regional urban housing policy within the framework of an overall planning strategy for the region. Though it was the first such housing policy for a major metropolis, it has yet to be implemented.

How many houses does Bombay need?

The need for new housing units generally arises on account of: (a) replacement of the existing slum housing stock and (b) building new housing stock for the increased population. Since limited resources make it impossible to replace all the houses in slums, the present efforts of the Bombay Housing and Area Development Board therefore rightly lay emphasis on the environmental improvement of slums and conservation and rehabilitation of the existing housing stock. However, the slum population grew from about 12 per cent of the total population in 1961 to 33 per cent in 1976. Such a proliferation of slums reveals our inability to build new houses on a scale which matches the increasing number of households.

What is the total number of new housing units that are needed? In 1976, the urban population of the region was estimated to be about 8.2 million. By 1986, it will grow to about 11.3 million—an increase of 600,000 new households. This means 60,000 new housing units are needed every year, over the next ten years, only to absorb the additional population.

Against this, during the [illegible] to 197[illegible] agencies built about [illegible] 2,000 [illegible] ope[illegible] particularly [illegible]

Any meaningful planning for the city can only be undertaken on a regional basis. ...Increasing the effective supply of land through development of new growth centres in the region should form a key feature of this regional housing policy

10,000 units per year. Similarly, the best performance of the private sector has been another 12,000 to 13,000 units a year. Thus against the need of 60,000 units per year, the maximum building capability achieved in the city so far has been around 25,000 housing units.

These figures can be misleading. For, a large number of these houses were built for the middle and upper income brackets. The vast majority of the city's population do not have the kind of capital savings which enable them to buy a house. Instead, they spend a considerable proportion of their monthly income as rent. Can we transform such monthly expenditure into capital assets? This will require credit and it is assumed that such credit will be made available on terms which are similar to those offered by HUDCO.

Table 1: Housing budget profile

Monthly household income Rs	Paying ability. Rs. per month	Credit available Rs. (per cent of the total cost)	Rate of interest (per cent)	Payment period (years)	Initial contribution Rs.	Total housing budget Rs.	Per cent of households
Less than 100	5	750 (75)	5	20	250	1,000	1
100 to 200	15	2,240 (70)	5	20	960	3,200	12
200 to 350	30	4,480 (70)	5	20	1,920	6,400	29
350 to 600	50	5,460 (65)	7	15	2,840	8,300	39
600 to 1000	115	9,600 (60)	9.5	12	6,400	16,000	15
1000 to 1500	250	21,000 (50)	9.5	12	21,000	42,000	4

This means that about Rs.35 crores will be required as housing credit annually. Although differential rates of interest are adopted, the scheme is equivalent to an overall interest rate of eight per cent, with a repayment period of 15 years. This implies an inherent subsidy for the housing sector, since the opportunity cost of money in the economy as a whole would be around 15 per cent, and any additional subsidy to the housing sector would only be at the cost of other priority sectors.

What kind of houses can people get?

In order to identify the most economical housing, we must take [illegible] only the cost of building [illegible] cost of land [illegible], the land component per square metre of floor area decreases, as the building goes taller; the value of land gets spread over a larger floor area. (This is expressed by a floor space index or FSI which gives the ratio of total built-up area to the area of the land.) But since the construction cost increases with increasing number of storeys, (owing to the higher structural strength necessary and lifts, pumps, etc) there exists an optimum number of storeys for a given land value, which minimises the total unit cost (land + construction) of housing.

An optimal solution for a land value of Rs. 50 per square metre is a ground storeyed structure (FSI 0.5) having a total unit cost of Rs. 460 per square metre. For a land value of Rs.1,000 per square metre, the optimal solution is a ten storeyed building (FSI 3.5) at a cost of Rs.1,750 per square metre. Thus the higher the land value, the taller the optimal building pattern and the higher the unit cost of the housing. In fact, given the housing budget profile shown in Table 1, we find that for a land value of Rs. 50 per square metre, 13 per cent of the households cannot afford even a one-room house. This percentage increases to 42 per cent for land values of Rs.100 per square metre, and to 96 per cent for land values between Rs.500 and Rs.1,000 per square metre.

But in Bombay island, most land is valued at over Rs.500 per square metre. Insisting on multistorey housing (even with as little as one room per family) implies massive subsidies over and above the aforesaid credit of Rs.35 [illegible] Rs.72 [illegible] per year, [illegible] accommodated on land valued at Rs.1,000 per square metre). Such subsidies are not likely to be available and the housing programmes must, therefore, be worked out within the context of available housing credit with minimal external subsidy.

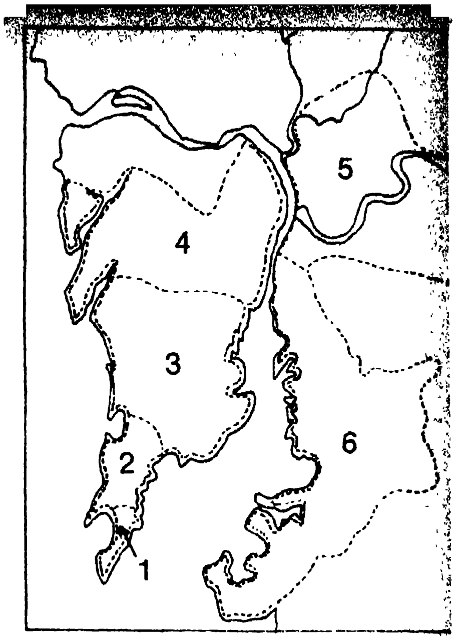


Fig. 1 Map of Bombay region. The approximate land prices in each sub-region are : 1. Over Rs 1,000 per m², 2 Rs 500 to Rs. 1,000 per m², 3. Rs 300 to Rs 500 per m², 4 Rs. 100 to Rs 200 per m², 5 and 6. Below Rs. 100 per m²

Housing policy

Theoretically speaking, every work-area generates a supply of usable residential hinterland in a full circle around its epicentre. But the geographical distortion of Bombay (a narrow peninsula in the rough shape of a 30 degree wedge) creates only one-twelfth of this theoretical supply. Moreover, the excessive concentration of jobs in south Bombay places a heavy demand on the already scarce supply of land, giving rise to astronomically high land prices. Increasing the effective supply of land through development of new growth centres in the region should thus form a key feature of the regional housing policy.

It is estimated that if the existing trend of concentration of jobs continues in south Bombay, the cost of accommodating an additional 600,000 housing units over a decade would be around Rs.800 crores; but if the trend of development is restructured by creating job opportunities at Bandra-Kurla (north-central Bombay suburbs), New Bombay (including Nhava-Sheva Port), and other growth centres in the region, the cost of housing would be about Rs.200 crores less than this amount. The

HOUSING STATISTICS

Population, households and housing stock (in million)

	1961			1971		
	Rural	Urban	Total	Rural	Urban	Total
Population	360	79	439	440	108	548
Households	68.7	14.8	83.5	78.0	19.0	97.0
Housing stock Pucca	12.1	6.3	18.4	14.1	11.3	25.9
Semi-pucca	23.1	4.9	28.0	27.9	4.3	32.2
Servicable kutcha	21.9			24.4		
		2.8	32.8		2.4	34.8
Other	3.1			8.0		
Total	65.2	14.0	79.2	74.4	18.5	92.9
Shortage	6.6	3.6	10.2	11.6	3.1	14.7

Housing shortage (In million)

	Rural	Urban	Total
Housing shortage as of March 1974	11.8	3.8	15.6
Housing shortage as of March 1979	14.8	4.9	19.7
Total annual requirement to close gap in 20 years by 1999	3.3	1.2	4.5

Investment

	First Plan 1951-56	Second Plan 1956-61	Third Plan 1961-66	Three Annual Plans 1966-69	Fourth Plan 1969-74	Fifth Plan 1974-79
Public sector investment in housing (Rs in crores)	250	300	425	250	625	1,044
No. of units built	47,764	127,771	277,021		99,452	133,554
Land sites to rural landless (in lakhs)					5.00	68.00
Investment in public sector housing as a percentage of total public sector investment	16.0	8.2	7.0		4.6	3.3
Private sector investment in housing (Rs. in crores)	900	1,500	1,125	950	2,175	3,636
Investment in private sector housing as percentage of total private sector investment	50.0	32.3	26.2		24.2	22.5

Sources Draft Five Year Plan 1978-83 (Planning Commission, 1978); Finance for Housing Schemes: Report of the working group on the role of the banking system (Reserve Bank of India, 1978)

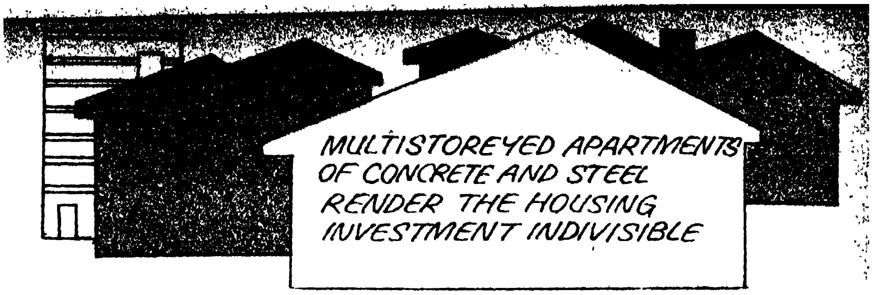
development of new growth centres would also save considerably on mass transport projects. (The underground railway project in Bombay has been estimated to cost about Rs.600 crores.) Development of new growth centres also involves control of already developed centres. This would require the formulation of location policies for industries, commercial establishments and offices.

Changing the concept of housing

The building specifications laid down by current municipal codes require the extensive use of steel, cement, bricks and other permanent materials. Because of the non-availability of long-term soft credit facilities, and the constraint on these materials, the municipal codes should not insist on present specifications. Instead, simpler structures of mud bricks, country tiles, etc, should be accepted. Such structures have the advantage of being improved from time to time as family savings increase. Each renovation or marginal extension could then be financed separately through individual savings and short-term credit. Multistoreyed apartments of concrete and steel render the housing investment indivisible as apartments cannot grow in size over a period of time. Such indivisibility of investment is a hurdle for poor people who want to divert some of their savings for housing. But the possibility of a renewable and incremental house would make housing more competitive with other sectors of consumption and act as an incentive to save.

Plots required for these houses can be extremely small, say 30 to 50 square metres (resulting in reasonably high net densities of 200 to 330 units per hectare). For motivating people to save and improve their houses, a long-term tenure of land, if not ownership, is a must; it not only psychologically motivates people to improve their houses, but also helps them raise loans in the money market.

As a corollary, it is obvious that the creation of shelter should move from the formal sector where architects design, engineers estimate and invite tenders, contractors build through sub-contractors, etc (all of which adds at least 15 per cent to the net cost of the shelter) to the informal sector


MULTISTOREYED APARTMENTS OF CONCRETE AND STEEL RENDER THE HOUSING INVESTMENT INDIVISIBLE

where the home owner himself builds or directly employs labour, thus pumping money and generating jobs in the bazaar section of the economy.

However, until measures for the dispersal of offices and factories from south Bombay are adopted, the exigencies of the near future would make provision of rental housing imperative. The public authorities should, therefore, undertake programmes of rental housing for the weaker sections of society.

Co-ordination of finance and housing

Since the solution to the housing problem is to be sought within a constrained credit policy, co-ordination of various housing and housing finance programmes is of vital importance. The existing credit facilities appear to be offering far less than what is reasonably repayable. Moreover, the credit offered has regressive effects since no credit is offered to the poor. In order to mobilise the required credit of Rs. 35 crores annually for the housing sector, the efforts of housing finance agencies (like HUDCO, LIC and the Maharashtra Co-operative Housing Finance Society Ltd) and housing development agencies need to be co-ordinated and these must necessarily be supplemented by the commercial banks. It is also essential that the available credit is used for housing the poor rather than the wealthy as has been the case so far. It is recommended that the credit available be distributed among various income groups as shown in Table 2.

Table 2

Income group	Per cent of credit recommended
Less than Rs.350	26
Rs.350 to Rs.600	36
Rs.600 to Rs.1000	24
Rs.1000 to Rs.1500	14

Physical targets

Today in Bombay the private sector (including co-operatives) has the capacity to build around 20,000 units a year. For the remaining 40,000 units, though the construction of houses should largely be left to people using the informal sector, land acquisition and development will have to be the responsibility of the public sector. Public ownership of land is crucial not only for recapturing the value added to land, but also for land rationing. For 40,000 housing units, about 250 hectares of gross land will have to be acquired and developed annually. Assuming that such land will be available under the Urban Land (Ceiling and Regulation) Act, 1976 (at a rate similar to that prescribed in the Act) an investment of Rs. 6.25 crores would be required annually for acquisition and development. Besides the development of land, construction would require an investment of about Rs. 28 crores.

Table 3 : Three-year programme of land development

Zone	Households	Net area required (Ha)	Outlay (lakh Rs.)
3. Greater Bombay suburbs	18,000	46.08	230.00
4 Greater Bombay extended suburbs and Thane	8,000	24.48	122.40
5. Kalyan complex and rest of the urban region	6,000	19.59	97.95
6 New Bombay	8,000	30.60	153.00
Total	40,000	120.75	603.35

The region has been broadly divided into six zones having different approximate opportunity costs depending upon the accessibility to job centres and level of scarcity. The land available for public housing in already developed zones is very limited and its opportunity cost so high that low-rise core houses are not viable; at the same time, buildings with higher FSI may not be feasible on account of resource and other constraints. It would not, therefore, be appropriate to undertake any public housing programmes in these zones. The new housing stock of 40,000 units may, therefore, be entirely allocated to the remaining zones.

The spatial distribution of housing stock to be created over the next few years will have to satisfy the following criteria: (i) that the immediate needs of sub-regions are satisfied; (ii) the option of pursuing the policy of developing new growth centres should also remain open.

Keeping in view the above criteria, two extreme distribution patterns can be conceived, one representing the continuation of the present trend and the other a vigorous growth of new centres. The immediate programme will have to strike a balance between the two, though in the long run the development of growth centres would be economical. Based on these considerations, an annual programme is suggested for the next three years in Table 3.

The programme is based on very aggregate and macro-level data, and hence it is only indicative of the direction in which the efforts should move. However, it does provide a broad framework within which firm, long-term programmes can be devised for each agency operating in various parts of the region. Co-ordination by the government (or BMRDA) of these programmes will be necessary to see that the housing sector is developing in the right direction.

Mr. Phatak is an urban planner with the Bombay Metropolitan Region Development Authority.

A LOW-COST TECHNOLOGY

Costs can be cut by using cheaper building materials and by lowering the cost of conventional materials. Better design of components also leads to substantial savings

Dinesh Mohan

ON THE face of it, there seems nothing unusual about Buddhiram's house in Ghaziabad, UP. A one-storey brick structure with one room, a kitchen-cum-verandah and a backyard with a bathroom and toilet, it seems like millions of other houses in north India. Buddhiram knows he paid 8,000 rupees for the house and considers himself lucky to have been assigned a government-built house which he could buy on loan. But what he probably does not know is that the same house would have cost him 11,300 rupees if it had been built like conventional houses. It would not have been any sturdier or more comfortable, and yet he would have had to pay 41 per cent more. It is this saving that makes Buddhiram's house and the other 1,550 houses in his colony so different—a total saving of Rs. 51 lakhs.

What made this saving possible is the application of indigenously developed construction technology. These 1,550 houses built by the Ghaziabad Development Authority thus represent one technical solution to the problem of low-cost housing in India.

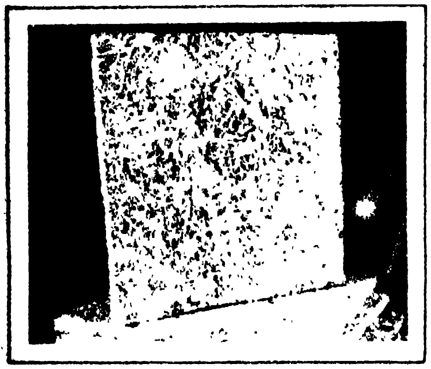
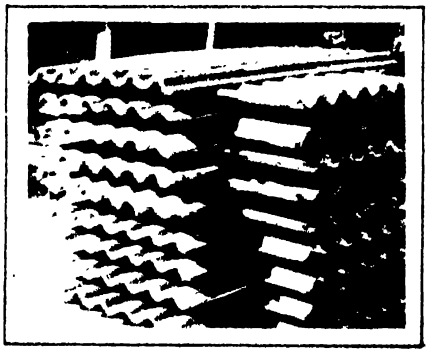


Fig. 1 (*above*) Woodwool boards and Fig 2 (*right*) corrugated roofing sheets made from coir waste

In fact, much of the research that has been done in India on construction materials and building techniques, has concentrated on developing a simple technology for low-cost housing. It has mainly centered on cutting costs and optimising on the use of scarce materials like cement and steel without lowering standards of construction. There are four main ways in which this can be done: selecting cheaper building materials; developing building techniques and designing housing components to make more efficient use of building materials; spatial design; and, proper management and implementation at the construction site. Of these, we shall discuss only the first two.

Building materials

Building materials such as brick, lime, cement, steel and timber, account for roughly 60 to 70 per cent of the cost of a *pucca* single or double-storey building. Though bricks are very commonly used, the brick industry in India currently faces several problems. Suitable clays are not widely available and there is a shortage of trained moulders. The quality of bricks made by the traditional hand-moulding methods is also poor. The Central Building Research Institute (CBRI) has developed techniques for producing good bricks from difficult soils like black cotton soil, morrum, sandy soils and kallar soils which were earlier considered unsuitable for brick-making. One way of using inferior soils like black cotton soils for brick-making is to mix them with grog (partially calcined clay). Bricks made by this technique are not only of good quality with a compressive strength of 50 to 70 kg/cm² (compared to 20 to 30 kg/cm² for normal bricks) but also have a superior surface finish. Such bricks would cost ten per cent more than conventional bricks but they reduce the overall cost of a building since thinner load-bearing walls can be used.



A semi-mechanised process of brick manufacture has also been developed for improving the productivity and quality of bricks; the machine can produce 2,000 bricks per hour. It can also produce structural clay units for floors and roof. A high-draught continuous kiln for burning building bricks has been designed such that bricks can be burnt throughout the year with a daily output of 150,000 bricks, more than 80 per cent of them being Class-I bricks. The total capital investment in this plant is eight to 10 lakh rupees, versus nearly one crore rupees for a fully mechanised plant.

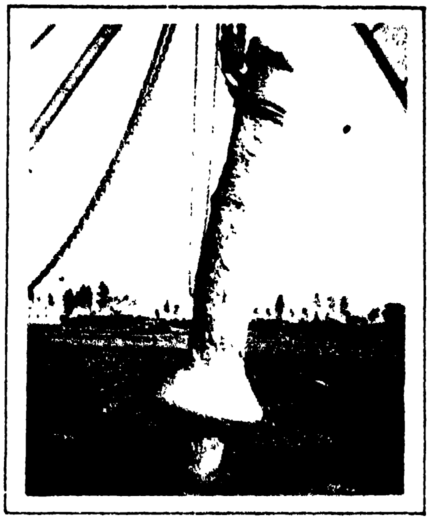


Fig. 3 Under-reamed pile removed for inspection

Till the development of Portland cement in the late nineteenth century, lime was the traditional binding material. Lime is cheaper than cement; though it is widely manufactured by smallscale industries, the quality is usually not uniform and is substandard. The CBRI has developed a more efficient kiln for better burning of limestone. The kiln is suitable for village industries and could cut down the consumption of fuel by about 20 per cent, besides improving the quality of the lime. Lime hydrators of capacities varying from two to 10 tonnes per eight-hour shift have also been developed.

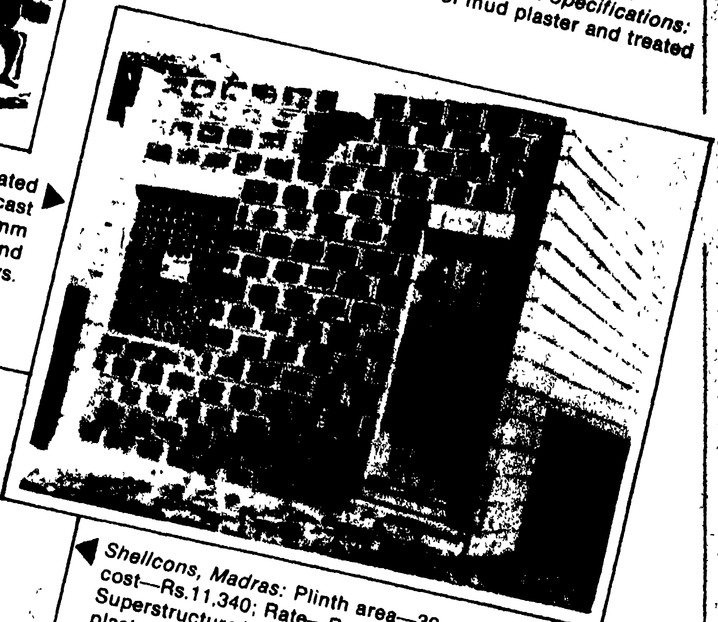
The search for cheap cementitious or binding materials is very important. During the past few years a wide variety of cementitious materials have been developed using industrial and agricultural wastes. One very abundant and thoroughly investigated material is flyash (SCIENCE TODAY, October 1979, p.41). It is a

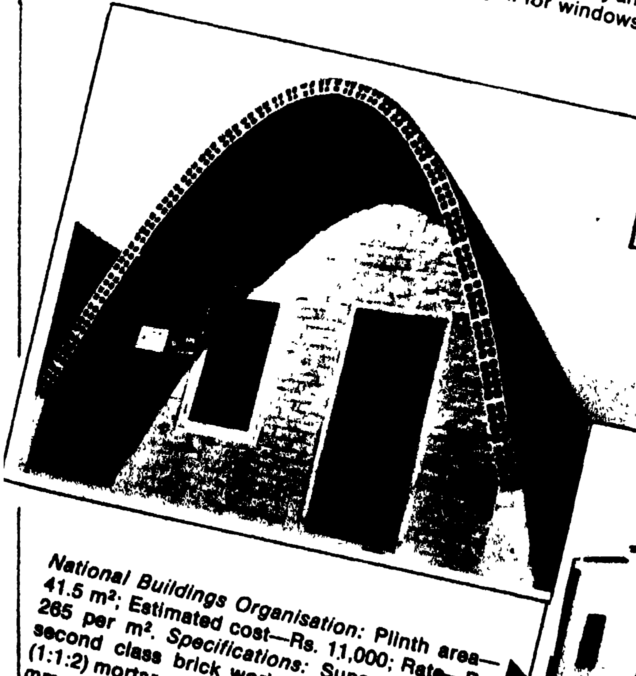
LOW-COST HOUSES

Rural Housing Wing, West Bengal: Plinth area—22 m^2; Estimated cost—Rs.2,620; Rate—Rs.119 per m^2. *Specifications:* Superstructure is in brick work in mud mortar with tiled roof over bamboo rafters, while flooring is rammed earth with mud plaster. ▶

◀ *National Buildings Organisation:* Plinth area—24.4 m^2; Estimated cost Rs.1,500; Rate—Rs.62 per m^2. *Specifications:* Sundried brick walls with waterproof mud plaster and treated thatch roof.

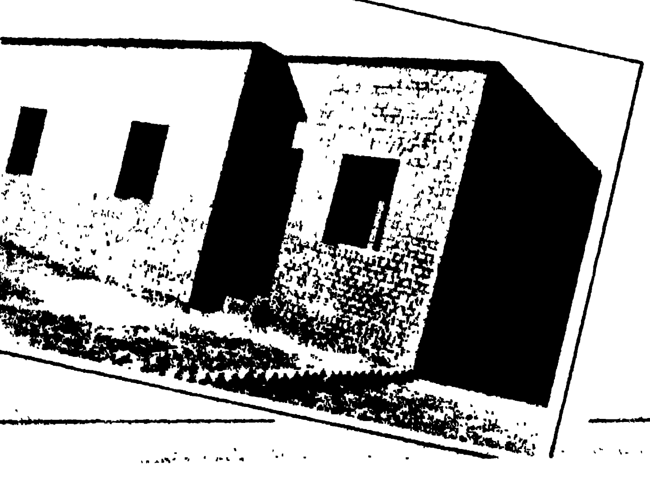
Rajasthan Housing Board: Plinth area—22.7 m^2; Estimated cost—Rs 3,790, Rate—Rs.164 per m^2. *Specifications:* Precast stone block masonry in lime mortar for superstructure and 75 mm thick stone slabs for roof with second grade wood for joinery and RCC grill for windows. ▶





◀ *Shellcons, Madras:* Plinth area—39 m^2; Estimated cost—Rs.11,340; Rate—Rs.291 per m^2. *Specifications:* Superstructure is of hollow clay blocks in cement mortar with no plastering. Foundation is brick work in cement mortar.

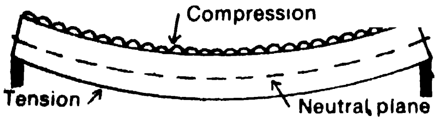
National Buildings Organisation: Plinth area—41.5 m^2; Estimated cost—Rs. 11,000; Rate—Rs. 265 per m^2. *Specifications:* Superstructure is second class brick work in lime, flyash, sand (1:1:2) mortar with channel units for roof and 25 mm cement concrete over flat bricks for flooring. ▶



From an exhibition of low-cost demonstration houses organised by the DDA and NBO at Ber Sarai in New Delhi. Cost estimate is based on November 1975 rates.

WHAT MAKES A ROOF STAND?

THE phrase, 'a roof over one's head' efers to a house, and it is the roof, more han any other component of a house, hat provides shelter from rain and the un. But why doesn't the roof fall on our eads? What makes it stay where it is?



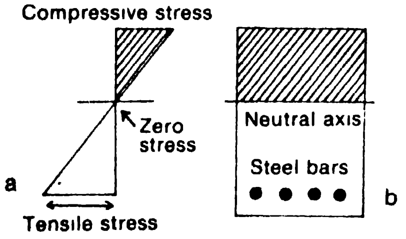


Fig. 1 (*top*) A simply supported, uniformly loaded beam. Fig. 2 (*above*) Cross-section of beam and stresses acting on it at various points

To understand this, let us consider various kinds of roofs. Roofs can broadly be classified as flat roofs, pitched (or sloping) roofs and formed roofs. The flat roof is commonly used for residential and office buildings. In areas of heavy rain or snowfall, pitched roofs are preferred, while formed roofs such as shells, domes or folded plates are sometimes used for auditoriums, exhibition halls and prestigious buildings.

In its simple form, a flat roof is a beam (a horizontal structural member which carries a load and transfers the load to the nearest support). The load on a beam includes the weight of the beam itself (the dead load), the live load, or the load placed on the beam, and the load due to wind and other incidental forces. The load causes the beam to deflect (Fig. 1) and this deflection leads to the top portion of the beam getting compressed and the bottom portion being tensed or elongated. In between lies a layer which does not undergo any change in length. This is called the neutral plane.

The force exerted by the load is thus translated into a compressive force or stress (force per unit area) at the top and a tensile (elongation) stress at the bottom portion as shown in the stress diagram in Fig. 2a. If a beam is to withstand the load placed on it, it must be able to withstand the tensile and compressive stresses generated by the load.

In conventional flat roofs constructed with timber or steel beams, the material can withstand almost identical compressive and tensile stresses. Thus, designing a roof for various loads and spans only requires the use of beams of a suitable cross-section. Concrete, however, is very good in compression but has almost no strength in tension. This property restricted the use of concrete for roofs until it was discovered that concrete could be reinforced with steel to increase its tensile strength. Since the steel reinforcement has to take only tensile stresses, it is placed at the bottom of the beam or slab (Fig. 2b) where the tensile stress is greatest.

In pitched roofs, the major design consideration is the horizontal thrust on the supporting wall. This is countered by having a horizontal bottom member which resists the horizontal thrust (Fig.4).

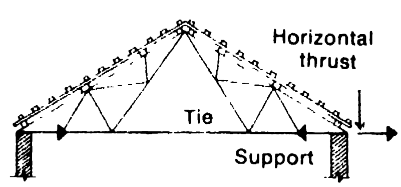


Fig. 4 A pitched roof

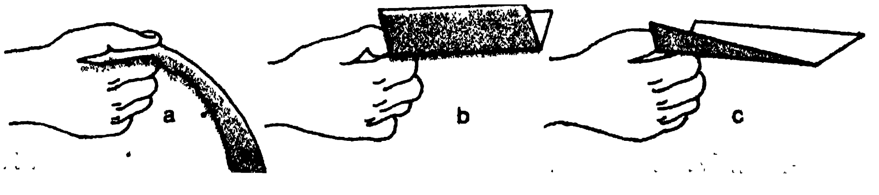
Formed structures are of various kinds. Before the widespread use of concrete, large spaces could only be spanned by domes or arches. Either brick or stone was used and it was bonded with lime. Since these materials can take very small tensile stresses, the dome was designed such that the load is mainly transmitted through compressive stresses. Domes have also been used for housing; the classic examples are the ice igloo built by the Eskimos and sun-dried brick domes used in parts of Egypt.

With the use of concrete, different kinds of formed structures became possible (Fig. 3). These roofs mainly derive their strength from the geometric form of the roof. The stresses in such roofs are very different from those in flat roofs.

R.N. RAIKAR

Mr. Raikar, a consulting civil engineer in Bombay, has written a book *Technology of Building Repairs.*

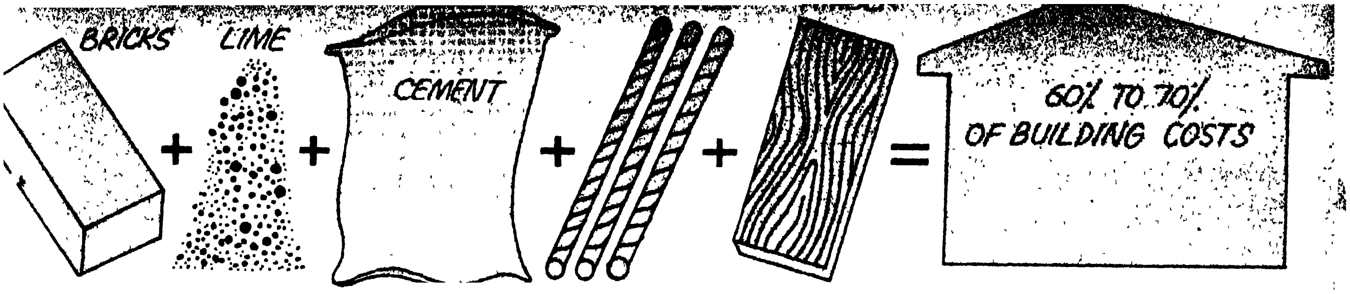
Fig. 3 The principles that apply to formed roofs are illustrated by comparing a reinforced concrete roof to a sheet of paper. The sheet of paper when simply held (a) has no strength all. But folding the paper sheet (b) by bringing the material away from the middle plane, increases its capacity to take bending stresses. This is the principle that is applied to folded plate roofs. Similarly, if a paper sheet is given a slight upward curvature (c) it can support a load



waste material from thermal power stations and contains silica, alumina, iron oxide and some carbon. It is possible to replace up to 20 per cent of the cement used in concrete mixes and masonry mortars by flyash. The compressive and flexural strength of the concrete or masonry is not affected; flyash cement mix is actually superior to ordinary cement in resisting the deleterious effects of acids, alkalies and sulphates. Besides, the cost is cut down by ten to 30 rupees a tonne. Flyash can also be used in brick and tile-making. Clay-bonded flyash bricks using 30 to 60 per cent (by volume) flyash with clay have been made.

A wide variety of other cementitious materials have also been developed, using industrial and agricultural wastes. High slag masonry cement using 70 parts of blast furnace granulated slag, 30 parts of cement clinker with a small amount of gypsum and air-entraining agent is one such binder with strength comparable to cement. Another binder is lime-sludge-based masonry cement using waste lime sludge available from sugar, paper, acetylene and tanning industries. In addition, lime sludge, rice husk and coconut pith, which are widely available as wastes, have also been used for making concretes and mortars. A hydraulic binder (or cement) from lime sludge and rice husk has been developed by mixing suitable proportions of rice husk and lime sludge and forming balls or cakes which are dried, fired and finally ground to the desired fineness. The compressive strength of this binder ranges between 28 and 50 kg/cm² after 28 days of curing. This compares favourably with the 30 to 50 kg/cm² strength for 1:6 cement/sand concrete.

Most houses in regions of heavy rainfall have sloping roofs made from either clay tiles, asbestos cement sheets, galvanised iron sheets or grass and palm thatch. The walls of many village houses are often constructed of reeds plastered with mud. Effective substitutes have now been developed using agricultural wastes such as coconut husk, coir waste and wood wool. Wood wool boards have been made by saturating wood wool with cement slurry and this is then compressed in the form of board. Particle board can be made from coconut husk.



in a similar way by hot pressing coconut husk chips. Corrugated roofing sheet from coir waste or wood wool can be made by soaking the coir or wood wool fibre in mineralised water for two hours after which the free water is drained off. The wet fibre is then mixed with cement and the roofing sheet is formed by pressing the mat on to a corrugated mould.

Components

Just as it is possible to view the construction of a building in terms of the materials used, it can be analysed in terms of its components. The major components of a one- or two-storey residential building would be the foundation, the walls, the roof, doors and windows, and services such as water, electricity and waste disposal. Major reductions in building costs are possible by suitably designing these components to optimise on the use of materials and labour.

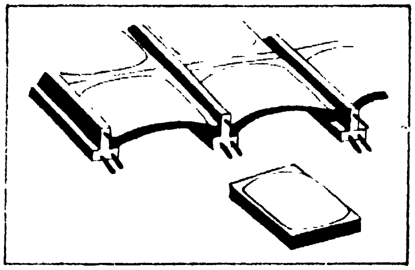


Fig. 4 Doubly curved tiles on precast concrete beams

The foundation is a very important structural component of a building and normally constitutes 10 to 15 per cent of the total cost. For a single-storey house, the depth of the foundation is generally kept at 50 cm in a normal hard soil. In regions of black cotton soil such as found in Madhya Pradesh, however, the swelling and shrinkage of the soil because of the variation in moisture content, poses a serious problem that could lead to the cracking of buildings on conventional foundations. The problem has been successfully tackled by the adoption of a technique known as under-reamed pile foundation which is fool-proof against cracking and is economical compared to conventional foundations. In this technique, a bore hole is made with a manually operated auger and an under-ream (enlarged bulb) is cut at the desired depth by a simple and portable under-reaming tool. The bore with the enlarged base is subsequently concreted by first placing a reinforcement cage. The piles (Fig. 3) normally have a depth of three metres. A plinth beam is constructed on these piles and the building is supported on this beam clear off the ground so that it is free from the effects of the swelling or shrinkage of the soil. This technique has now been included in the National Building Code and has been adopted in thousands of buildings, effecting considerable economies in foundation costs.

Economies are also possible in walls. Functionally, walls not only enclose the space within a house but often take the weight of the roof and upper storeys. Various walling techniques have been developed in the country which are economical and allow for speedier construction. These include: single thickness load-bearing brick walls; stone masonry blocks; thin cavity walls and hollow cement concrete block masonry. Thin cavity walls and single-brick thick walls are generally suitable for all regions of the country except the Kashmir Valley, Himachal Pradesh and the hilly areas of UP where stone block masonry will prove economical because suitable stones are locally available.

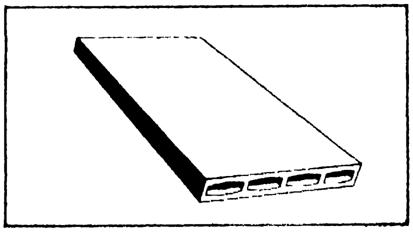


Fig. 5 Cellular unit

In areas where stone is available abundantly, the technique of walling with precast stone masonry blocks has become popular. These blocks are normally of size 30 x 20 x 15 cm, and use stones up to 12 cm in size and a lean cement concrete mix of 1:5:8 (cement, sand and gravel) is cast in steel moulds; it is demoulded within five to seven minutes. Each block weighs around 18 kg and its compressive strength is 70 to 90 kg/cm² (as against 50 to 60 kg/cm² for bricks). For partition walls, blocks of size 30 x 10 x 15 cm are used. The casting technique is such that one face of the block gets a natural stone texture. A 20-cm thick stone masonry block wall gives a saving of about 16 per cent as compared to conventional random rubble masonry, besides providing a greater floor area for the same plinth area. This technique is now being successfully adopted by a number of organisations including the Rajasthan Housing Board and the Public Works Department, UP Housing Board, Andhra Pradesh Housing Corporation, Delhi Development Authority and the Himachal Pradesh Housing Board.

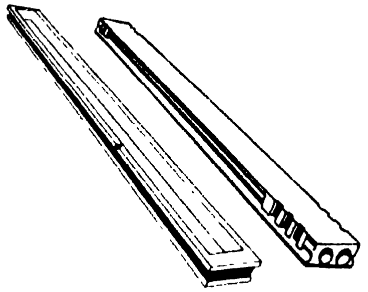


Fig. 6 Channel unit *(left)* and cored unit

The roof has traditionally been the most expensive component of a building; it can take up to 25 per cent of the total cost. Except when sloping roofs using tiles or asbestos sheets are used, the most common form of roofing has been the use of reinforced concrete (RCC) slabs. The discovery that concrete reinforced with steel bars could form a flat roof for a building was itself a major stride in construction technology. Earlier, flat roofs had to be supported by a number of steel or wooden beams which made them more costly and difficult to build. However, since RCC slabs for roofing in single and multi-storey buildings have now become the norm, a major thrust in the development of a technology for lowering construction costs has been directed towards finding alternative roofing techniques.

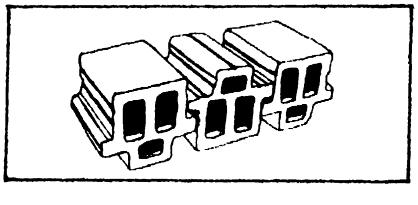


Fig. 7 Structural clay units

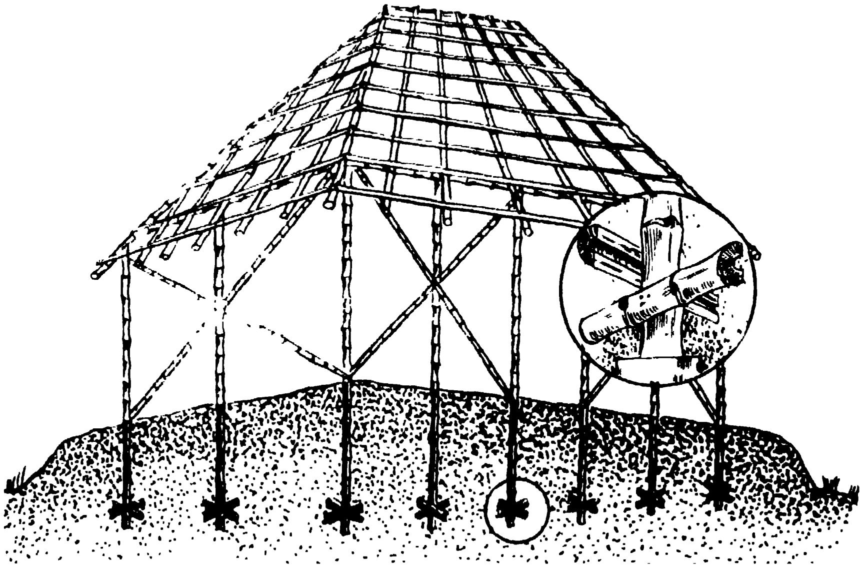
RURAL HOUSING

THE rural housing shortage in India was estimated in 1979 to be 14.8 million houses. This included a substantial portion of the *kutcha* houses in the villages. Unlike urban houses, rural houses show a wide variation in design and method of construction from district to district. These designs have evolved over many centuries and they therefore represent an optimal solution to local housing needs, given the availability of building materials in the vicinity. Though non-traditional materials such as bricks, cement and steel are now being used, traditional materials such as locally available stones, lime, timber, bamboo, mud, reed, tiles, straw and thatch are still widely used.

Traditional materials will continue to be used until such time as it is possible to build *pucca* houses for all the rural families. However, it is possible to vastly improve the performance of these materials by a minimum input of modern materials or techniques.

The durability of mud houses, for instance, can be substantially increased by stabilising the mud by adding two to five per cent cement, or cement and lime. Similarly, the life of local timber or bamboo structures can be increased by treating them suitably to protect them against insect and termite attack. One such preservative is a mixture consisting of three parts of copper sulphate, four parts of sodium dichromate and one part of arsenic pentoxide dissolved in 100 parts of water. The timber or bamboo is treated by dipping or soaking it in the solution. Grass or palmyra thatch can also be similarly treated for protection from insects and fungi and their normal life can be increased from around two years to around 12 years.

In some parts of the country, such as parts of Bengal and Assam, rural houses are made with bamboo posts and reed walls plastered with mud or lime. The bamboo posts also act as a foundation. Such structures can be considerably strengthened by bracing the posts with diagonal members. The foundations can also be strengthened by fixing two pieces of split bamboo crosswise near the bottom and applying coal tar to the bottom part of the post for protection against insects



Conventional bamboo-framed house that is strengthened by bracing the frame with diagonal members Inset shows how foundation is strengthened

In fact, most existing rural houses can be improved a lot with a minimum of investment. Village houses are generally ill-planned, ill-ventilated and insanitary. The NBO suggests the following improvements in rural houses:

The floor-level of the house should be raised 30 cm above the adjoining ground.

Windows should be provided for adequate light and ventilation.

Roof height should be raised to provide 2.0 m clear headway.

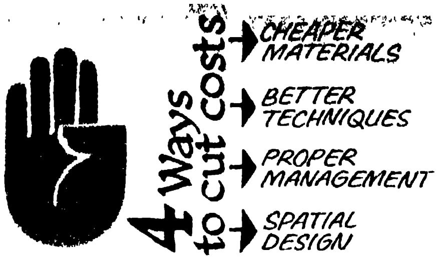
The roof should be laid with treated thatch or country tiles.

The walls should be plastered with water-proof mud plaster as described earlier.

A separate cattle shed should be provided at the rear of the house.

A sanitary type latrine should be provided.

To encourage and help such improvement, official village housing schemes should grant loans for house improvement works also, and not only for building new houses.



The techniques largely aim at a form of prefabrication to eliminate the elaborate wooden scaffolding and formwork that is necessary for RCC slabs. The designs of the units ensure optimum utilisation of cement and steel, thereby reducing the overall cost, apart from cutting short construction time substantially.

There are five innovations in roofing techniques that have been extensively tested and which are also easy to mass-produce.

Doubly curved tiles are 70-cm square and 2-cm thick concrete units having curvature on all four sides and all the four edges in one plane and level. They are cast in timber moulds to which a hessian cloth is fixed with headless nails. These units are placed on partially precast reinforced concrete beams at 75 cm centres and the haunches are filled with concrete to act as T-beams. This design results in a saving of 28 per cent cement as compared to conventional RCC slab construction, but since these units cannot take a heavy load they are recommended for roofing purposes only.

Fig. 8 Precast stone masonry walling

Cellular units are unreinforced hollow precast concrete units of size 120 cm x 60 cm and 7.5 cm thick. These are cast in timber moulds and the cores are created by wooden framework with wedges wrapped with rubber sheeting. These are used with partially or fully precast beams for normal residential roof/floor loads. This design results in a saving of about 20 per cent cement as compared to a conventional RCC slab.

Channel units are reinforced concrete trough type units 30- to 60-cm wide and 15-cm deep and are suitable for spans from 2.5 metres to 4.5

Fig. 9 *Sarvatogriha* type house built with bricks, mud and lime. The curved roof needs no steel reinforcement

metres. Channel units are cast manually, upside down on a concrete platform and removed for curing after 24 hours of casting. The joints between the units are filled with poured concrete. This results in a saving of 40 per cent cement when compared to a conventional RCC slab. These units have been successfully adopted in thousands of primary schools constructed in UP.

Cored units are hollow reinforced concrete box-type units which are suitable for spans from three to 4.5 metres. They are self-supporting and do not require any propping. They are placed adjacent to one another and the joints between the units are filled with concrete, after placing the reinforcement for negative moments at continuous supports. The scheme results in a saving of about 25 per cent concrete when compared to a conventional slab.

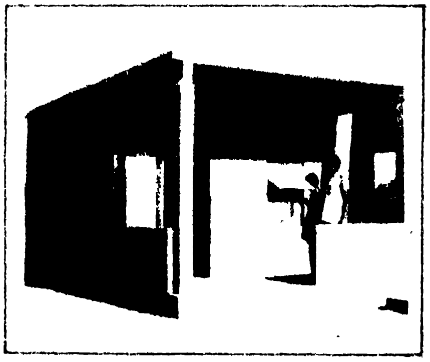


Fig. 10 Concrete skeleton system house with sundried brick walls

Structural clay units are manufactured with an extrusion machine. They are hollow clay units which can be used as structural elements. Two types of structural clay units have been developed at the Central Building Research Institute (CBRI), Roorkee. The first type is suitable for joist and filler block construction. (In this type of construction the units are placed end-to-end to form a beam, and between two such beams, units are supported as a filler block.) With the second type of units, the floor or roof panels are built vertically like a brick wall with desired reinforcement placed in the grooves of the units. These floors/roofs are about 20 per cent lighter than an RCC slab and save ement (45 to 65 per cent) and steel (20 to 25 per cent).

Besides innovations in the design of building components and techniques of construction, there have been many attempts to develop building systems that can be used for the construction of an entire house. The advantage of these systems is that they are cheaper, can be partially prefabricated and mass produced, do not require special building skills and can be constructed very rapidly. While it is not possible to examine each system in detail in this article, some of the more important features of each are presented here.

Building systems

The Holopan system is one such system. It refers to a form of construction employing hollow prefabricated plain concrete panels. Basically, it is a frame and infill type of structure where the frame consists of vertical reinforced concrete columns cast in situ between the precast hollow panels. The size of the wall panel is 70 cm x 1 m. The system has only eight different types of elements. Precast roofing beams support the floor/roof hollow panels of plain concrete which are 1 metre square. All elements are prefinished, and the weight of most of the elements is below 80 kg, thus enabling them to be handled manually. This system has been adopted for the construction of a colony of industrial workers at Ghaziabad.

The technique of concobrick construction for roofing and flooring exploits the properties of brick and concrete to form a composite roof or floor with efficient use of both materials. The technique combines the good points of traditional jack-arch (60 degree arch) roofing and modern concepts of prefabrication. The two precast components utilised in the construction are arch panels of bricks and composite I-beams of precast concrete. The roof/floor is constructed by putting the arch panels on partially precast I-beams. Concrete is laid over to fill the haunches and form an integral structure with the I-beam. The roof is finished after placing a 50-mm thick layer of mud and wheat-straw mix and/or lime concrete for thermal insulation and water proofing.

The concrete skeleton system consists of five types of precast components. As the name suggests, this system provides the 'skeleton' of a house. The five precast components are: pocket footings, hollow columns, small beams, joists, and unreinforced doubly curved tiles. The components can be cast in timber moulds at the site itself or at an urban centre and later transported to the site. They are so designed that they are light enough to be handled manually during erection and placing. After the skeleton is erected and the roof is laid, cladding walls of any available materials may be put up and doors and windows of locally available timber may be fitted. This system, apart from being durable, introduces prefabrication, leading to faster construction and flexibility; it is also labour intensive. It also has the advantage that once a 'skeleton' is complete (at about half the total cost of the house) the occupant can later add *pucca* flooring, etc in stages, as and when he acquires the resources. The concrete skeleton system has been used experimentally for the construction of 42 houses in Karimnagar (Andhra Pradesh) and about 300 houses under the UP Harijan Housing Scheme in Meerut, Bulandshahar and Varanasi districts.

For hilly and other areas where timber is abundantly available, the CBRI has developed a timber skeleton system, using secondary species of timber instead of scarce and costly timber like teak and sal. The other distinctive feature of this scheme is the use of small-dimensioned timber sections with a maximum length of 1.2 metres, which reduces wastage and facilitates air seasoning. The structure consists of a truss supported over columns and is roofed with asbestos cement sheets. The column and truss are fabricated with nails and short timber pieces and are then assembled together with bolts. The member can be fabricated at the site or at a central fabrication shop and assembled at site. The columns are fixed with the help of mild steel angles and bolts.

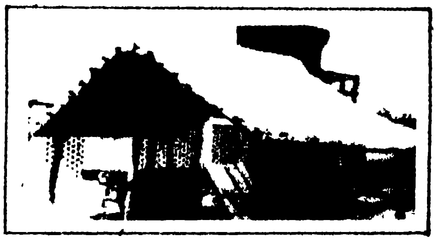


Fig. 11 Fire-retardant thatch roof

Rural housing

Realising the need for rural housing, attempts are being made to develop building technologies which reduce or eliminate the use of cement and steel. *Sarvatogriha* (Fig.9) is one such attempt which promises to provide durable dwellings through the use of local resources and skills. The method of construction of this type of house is similar to that of a shell structure but the important difference is that no shuttering is used. This is made possible by cutting a groove in one supporting wall such that the groove follows the shape of the curved roof. The bricks comprising the roof are then laid in the desired shape without any need for shuttering. They are placed such that bending stresses are very small and the load is transmitted primarily by direct stresses. This design has two main advantages. Firstly, it mainly consumes bricks, mud and timber—all of which are locally available in most villages. Secondly, its construction method is simple and eliminates the need for shuttering; therefore, it does not require highly skilled building workers.

Since village houses are very often mud and thatch structures that have to be repaired after each monsoon, any innovation that improves these houses at a low cost would be useful. The mud walls can be made waterproof merely by plastering them with a thin coat of bitumen-stabilised mud plaster. Only about two per cent bitumen, thinned with kerosene, is used. Again, thatch roofs which are prone to decay and are easily inflammable, can be made more durable and fire-retardant by applying a coat of bitumen-stabilised mud plaster on either side. The additional cost incurred is very small, while such treatment greatly increases the life of these structures.

Conscious efforts to solve housing problems are continuously bringing forth innovations from various research and construction organisations in the country. However, their widespread implementation in the field encounters a number of difficulties. Besides the general resistance to change, other obstacles include the process of tendering and award of work, the lack of a devoted band of field technicians and the lack of facilities (organisational as well as financial) for skilled workers to learn the newer skills. Considerations of economy and the necessity of putting to use and testing innovations in the field of house construction make it imperative that these obstacles be removed as quickly as possible.

Mr. Mohan is Director of the Central Building Research Institute, Roorkee.

SITES AND SERVICES

It is the government policies which are responsible for the creation and continuing existence of slums

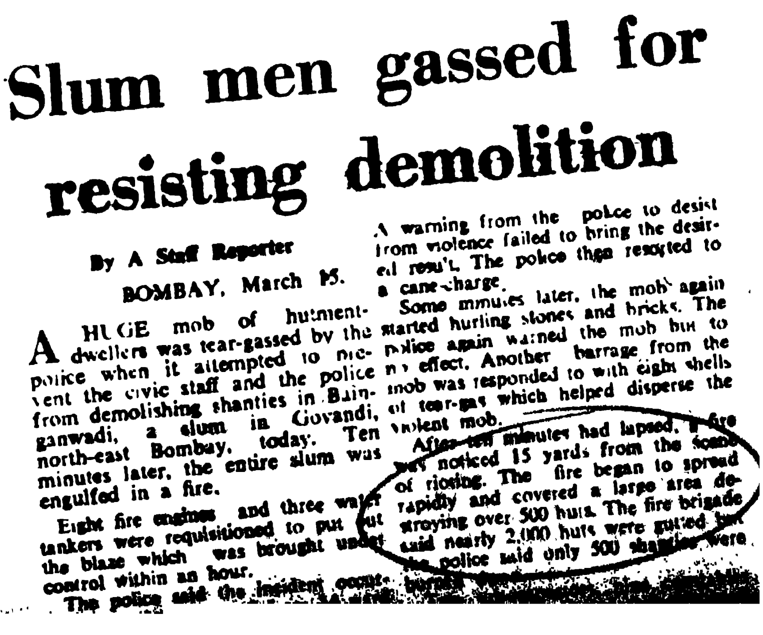
Shirish Patel

A LARGE section of our urban population lives in slums or *zopadpattis*. To those who do not live in them, *zopadpattis* are objects of loathing and dread. Loathing because they are often insanitary and foul. Dread because the settlement is usually illegal, and one assumes that the act of lawlessness which brought about the *zopadpatti* is only the first of a continuing series of lawless acts by its very poor inhabitants. They must be criminals or drunks, because what self-respecting person would want to live in such a slum? And it is this initial, instinctive hostility which if not overcome prevents any kind of understanding of why *zopadpattis* come about, and what can be done about them.

None of our major cities is without slums, and many of the smaller cities have them too. They have increased greatly since independence, and a planned city like Chandigarh seems to be as badly afflicted as other towns of similar size, except that planning and vigorous policing keep the *zopadpattis* outside a particular boundary line. But why have they developed, despite the planning?

The trouble is that in our dreams there are no poor people, and so there were none in our plans either, especially in the early years. Chandigarh, in its plans, has no place where the poor or very poor can stay, but like all other cities it has jobs which only the poor or very poor will do, like domestic service, or shining shoes, or washing cars, or hauling goods in a handcart, jobs which the properly housed residents need done without having to enquire as to where the person who is filling the job is staying. Having literally nowhere to stay, no house he can afford, no place where it is *legal* for him to live, he can either sleep on the footpath, or on some vacant piece of land with a few cardboard or tin sheets put together to protect him from the weather. Water must be fetched from wherever it is available, often great distances away; for sanitation, since the public authority provides no facilities at all, the fields must serve instead, or the no man's land along the railway track. It is not by choice that *zopadpatti* dwellers live as they do: they have no choice.

It is the government and government policies which are responsible for the creation, continuing existence and expansion of *zopadpatti* areas. Those who live in them are as responsible for creating *zopadpattis* as babies are responsible for being born. Indignation at migrants entering the city is as misplaced as indignation at babies being born into an already overpopulated world. The government encourages the creation of more jobs in the city. Industries are licensed and can set up their headquarters there and expand their employment, private companies can



Slum men gassed for resisting demolition

By A Staff Reporter

BOMBAY, March 15.

A HUGE mob of hutment-dwellers was tear-gassed by the police when it attempted to prevent the civic staff and the police from demolishing shanties in Baiganwadi, a slum in Govandi, north-east Bombay, today. Ten minutes later, the entire slum was engulfed in a fire.

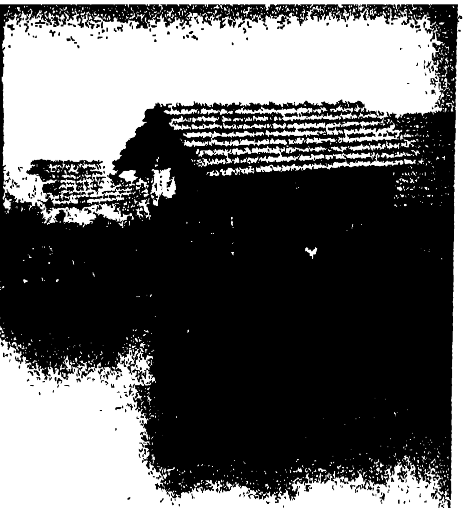
Eight fire engines and three water tankers were requisitioned to put out the blaze which was brought under control within an hour.

The police said the incident occur

A warning from the police to desist from violence failed to bring the desired result. The police then resorted to a cane-charge.

Some minutes later, the mob again started hurling stones and bricks. The police again warned the mob but to no effect. Another barrage from the mob was responded to with eight shells of tear-gas which helped disperse the violent mob.

After ten minutes had lapsed, a fire was noticed 15 yards from the scene of rioting. The fire began to spread rapidly and covered a large area destroying over 500 huts. The fire brigade said nearly 2,000 huts were gutted but the police said only 500 shanties were burnt



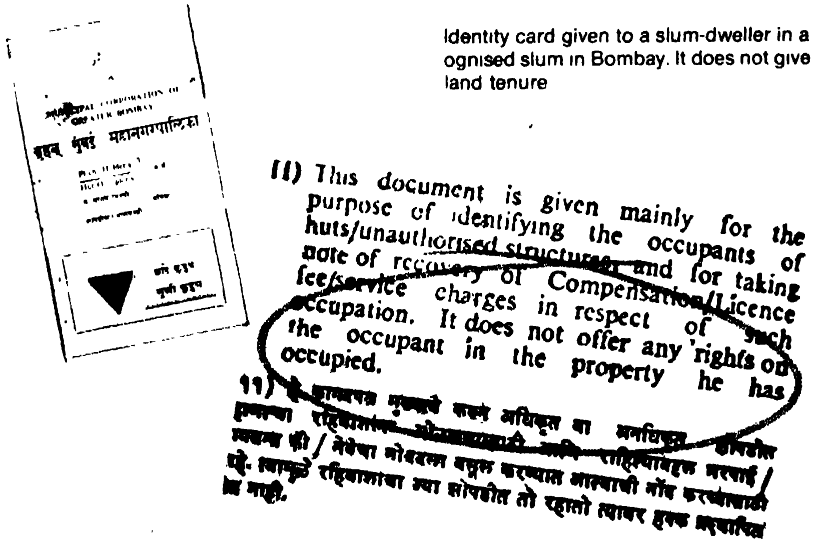
create as many urban jobs as they like, and none of these employers has to trouble himself as to how his employees will be housed, or where they will live.

Thus when the Department of Atomic Energy (DAE) declares it has vacancies for a hundred *malis* in Bombay, and these vacancies are filled, where will these *malis* live, if not in a *zopadpatti*? Who is then responsible for these *zopadpattis*—the *malis* who live there or the DAE? You are not the less responsible for a crime because the final act is committed not by you, but by your hired hands. When the DAE creates a hundred *malis'* declared vacancies, it also silently creates a hundred *zopadi* homes. Not that this should matter. Let us accept the fact that in our economy we simply cannot afford to properly house these *malis*. Let us accept that the DAE can afford no kind of housing for these *malis* at all, that they must live in shelters they put up with their own existing resources, without loans or other facilities. The tragic and crowning touch is that the *zopadis* are *illegal,* and the *malis* are law-breakers.

Whatever evidence we have from surveys indicates that *zopadpatti* residents are no less law-abiding and no less respectably employed than the rest of us. In 1976, a census of the Janata Colony at Trombay on the outskirts of Bombay showed that it had 1,200 workers employed in the DAE complex (*malis,* fitters, bus drivers, electricians), over 2,000 dock workers, over 600 employed by the Bombay Municipal Corporation, 125 State and Central Government workers, over 170 mill workers, 360 women employed in the DAE housing colony as domestic servants and so on. These people are not parasites. They perform essential urban functions, and they have as much right to a legally permitted dwelling place in the city as anyone else.

Lawlessness is not something to be encouraged, either explicitly or inadvertently. It has a multiplying effect, successful law-breaking in one field only encourages attempts in some other area. The illegal occupation of land, if successful, only brings the law into contempt. If those who must live in *zopadis* are not legally permitted to build these *zopadis* at specified locations, they will build them wherever they can get away with it. It is also no use permitting *zopadis* at impossibly remote locations. The residents are holding down jobs in the city, very often poorly paid jobs, and must be able to afford the cost of travelling. *Zopadpatti* areas need to be chosen in relation to the locations of jobs, and cannot be placed too far away, as these are the residents who can least afford to travel.

What turns a *zopadpatti* into a slum is not the fact that the houses are made of flattened kerosene tins, or bamboo matting or cardboard: it is that the place is insanitary, the rubbish not collected, there is no water supply or no electricity. If these services are introduced, toilet blocks built, public water taps provided, the lanes between houses paved and streetlights installed, the place becomes quickly transformed into a residential area preferable to some of the atrocious *pucca* public housing that is being built, and that besides at a fraction of the cost of the *pucca* housing. For those who want to see this for themselves, the "October 2 Colony" at Parel (Bombay) is a good example. This was originally an illegal squatter settlement, "regularised" by the municipality and the services put in. Incidentally, it should be recognised that when because of past policies certain illegal settlements have inevitably occurred, and when these are on public lands where they can be permitted to continue without



Identity card given to a slum-dweller in a recognised slum in Bombay. It does not give him land tenure

(I) This document is given mainly for the purpose of identifying the occupants of huts/unauthorised structures and for taking note of recovery of Compensation/Licence fee/service charges in respect of such occupation. It does not offer any rights on the occupant in the property he has occupied.

distress to anyone, it will promote a respect for the law to regularise them and thereafter discourage further illegal encroachments than to continue the daily demonstration of the impotence of the law in the face of this illegal but morally justified occupation.

Investment is related to risk. If a *zopadi* dweller feels that he is likely to be evicted at any moment he will spend as little as possible on his shelter, or at best see to it that it is made of salvageable materials to minimise loss in case he is forced to move. If, on the other hand, he is given reasonable assurance of security of tenure he will not only try to build a better dwelling, but will continue to improve it over the years. The Janata Colony at Trombay was an officially authorised *zopadpatti* settlement, with the municipality collecting regular rental from the plots, with plots properly designated and marked out and allotted, and with services provided. In that area, where security of tenure was reasonably assured, some residents had built proper brick houses, apart from mosques, temples, churches and other amenities. The colony also contained the finest example I have seen of a house in corrugated iron, designed and built by two electricians who lived in it. Pride in their work and a confidence and optimism concerning the future was reflected in the attitudes of these men. Unless they had been sure of their tenure they would not have spent the money or lavished the care that they did on their house.

Sites and services is a variously understood term. In essence it means recognising that those who cannot be provided proper housing in a city, and who must therefore live in *zopadpattis*, have a right to at least a piece of land (the "site") which they are legally permitted to occupy, with an assurance that they will not be arbitrarily evicted. This fact alone will ensure that they build better dwellings for themselves and improve them over the years. It also means that although the city may not be able to provide them with houses, it does undertake to provide them with the basic amenities of water supply, sanitation, street lighting, electricity and garbage collection (the "services"). It means, in effect, accepting the fact that the poor people in a city are an integral and essential part of the city's life, that they have as much right to live there as anyone else, and that, therefore, the city undertakes to provide them with a basic level of services and a legal right to stay.

Mr. Patel is a consulting engineer in Bombay. He was Director of Planning and Works in the City and Industrial Development Corporation of Maharashtra from 1970 to 1974.

CALCUTTA'S BUSTEE IMPROVEMENT PROGRAMME

ONE out of every three persons in Calcutta lives in a slum, the second lives in refugee colonies and other forms of edge-city settlements and only the third may be considered to live in what might be called the city proper. In the 'seventies, as redress for a history of total civic neglect, the Central government and the State government of West Bengal embarked on a massive programme of upgrading the utilities in the city slums. Called the Bustee Improvement Programme, it has so far covered some two million people while the remaining one million are expected to be covered in the 'eighties. Besides, a separate programme (all of this being under the Calcutta Metropolitan Development Authority, CMDA) has tackled the living conditions of some one million out of the 2.5 million refugees who have settled on the fringes of the city. Taken together, and given that the work and its implementation have evolved over ten years, this is a massive experience in institutional intervention in the general field of housing.

The programme that the CMDA has taken up in slums relates to a broader situation of deteriorating municipal services which started in the 1930s and had more or less collapsed by the 1960s. Parallel to this disintegration was the influx of an officially estimated 2.5 million refugees between 1947 and 1971, of which over one million came in the four years from 1947 to 1951. Administrative services and structure were found totally inadequate in coping with the situation and the temper of people throughout the city's settlements reached, and often passed, the breaking point.

In this situation, the Central and the State governments decided to take up, on a crash basis, the improvement of the settlements of the poor in the city. A central target was the bustees. These slums, unlike in many other cities, are not squatter settlements, containing transitional populations or illegal housing. (Such squatter settlements do exist in Calcutta. In fact, the city has nine different types of settlements of the poor—conventional bustees, squatter settlements, industrial worker housing slums, centre-city tenement slums, legal refugee colonies, extra-legal refugee settlements, pavement dwellings, normal [illegible] housing, usually in the suburbs, and bustee resettlement schemes.) This article only deals with the first category, that is, conventional bustees.

Conventional bustees are legalised permanent settlements, with a tenure system which is perhaps unique to Calcutta. This tenure system is also fundamental to their functioning, and a basic factor to be considered in any plans for change. There is a three-tier system: the land is owned by landlords who lease it out to persons called *thika* tenants. The *thika* tenants erect structures, and let these out to *bharatias*. The *bharatias* are the main inhabitants of the slums, though many *thika* tenants also live in bustees. The *thika* tenants collect rent from the *bharatias*, and in theory pay rent for the land to the landlord; in practice, this payment has either often lapsed or remains at a historically established and now negligible level.

Physically, bustees consist of huts made of mud, bamboo and, occasionally, brick walls, roofed with *khola* tiles. Passages in between are narrow, tortuous, and generally also serve as drains for the slum. Water is generally taken from derelict ponds which often exist at the centre of the bustee (because the settlement has been built up 'inwards' from the surrounding roads) and into which many drains empty, or from polluted wells, or the few street-side taps providing potable water. Sanitation services normally consist of service latrines, from which excreta is periodically collected manually in buckets. Houses are generally without electricity and passages and streets remain dark at night. Bustees are never uniformly residential; they are also significant production centres and locations for smallscale industries. Nevertheless, bustee residents mostly work in the tertiary sector, and average incomes are very low. Communities are often ethnically heterogeneous. Even their industries are dominated by middle men (who are sometimes the *thika* tenants), who provide both capital and raw material. A relatively low level of literacy prevails.

Any attempt to improve bustees therefore is compelled to involve the landlords, *thika* tenants and the *bharatias*. Historically, various legislations have been passed to improve bustees, but the complexity of the three-tier structure has not been anticipated, and counter-productive effects have occurred; consequently, new legislation has had to be invented. The West Bengal Slum Areas (Improvement and Clearance) Act, passed in 1972, represented a new approach. Firstly, it is more pragmatic than earlier Acts on most grounds; besides the question of redress for neglect, it accepted that bus-

Phase of operation	Period of coverage	Population in slums and portion of refugee colonies covered or to be covered under the programme in 100,000					Approx. cost (in Rs. million)	Approx. cost per capita (in Rs.)
		Calcutta	Howrah	East bank	West bank	Total		
I	1971-80	12 45	4.02	0.73	0 66	17.86	237.00	133
II	1977-82	4.26	0.50	0.30	0.20	5 26	210.00	400
III	1983-	—	—	4.97	1.64	6.61	330.00	500
TOTAL	1971-	16.71	4 52	6.00	2.50	29.73	777.00	259

Source : Bustee Improvement and Municipal-Anchal Development Sector, CMDA

tees are valid and productive socio-economic entities, even if they are a product of the capitalist system, and that they cannot just be 'removed'. It also accepts that the replacement of this enormous housing stock by conventional structures is far beyond the means of the state in any foreseeable future. And ultimately, it is designed so as not to interfere negatively with the rights of any of the members of the three-tier system.

The basic deficiencies being tackled under this programme are sanitation, water supply, and access, with the following norms for improvement: (i) conversion of existing service latrines to sanitary latrines or construction of new sanitary latrines on the basis of one latrine for each hutment or for every 25 persons, whichever is advantageous; (ii) potable water tap connection to individual huts or for every 100 persons with an average water supply of 90 litres per person per day; (iii) surface drainage facilities through underground conduits connected to the underground sewer system where available, or open surface drains discharging into the nearest open drainage channels; (iv) paved roads, streets and pathways within the bustees; (v) security lighting of streets and pathways; and (vi) miscellaneous facilities such as garbage vats, dustbins, bathing facilities, etc at suitable locations.

Learnings

The simplicity of the programme meant that it could be widely implemented, as is evident from the table above. The table clearly shows that the per capita cost of the improvements has risen steadily, from an initial level of Rs. 120, to the current Rs. 300 to Rs. 400. Although this is partly because of a rise in prices, this change also reflects a fundamental change in the philosophy of the programme. When the programme was started in 1970, the aim was quick completion. Work was undertaken in an ad hoc manner: slums were chosen for improvement, and with the barest of knowledge of their social and physical structure, engineers drew up plans, and then 'moved in' for implementation. Residents were not consulted prior to this phase, and indeed, at the early stages of a very big programme, there was little consultation with local municipal or civic authorities.

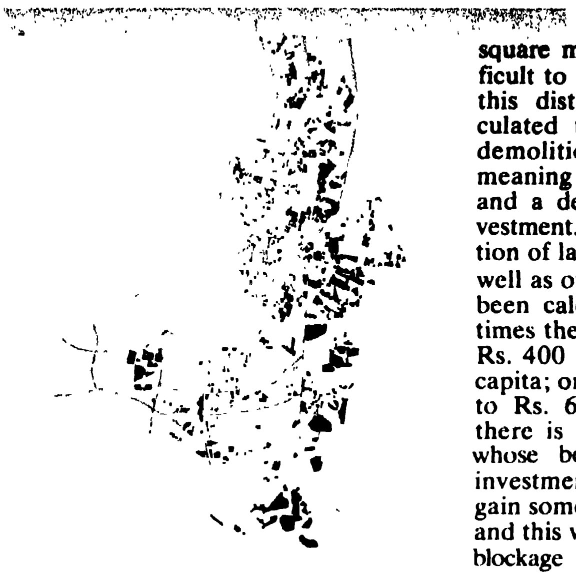
Rapidly, experience showed that this approach did not work without the co-operation of local people and local organisations to help them modify the ideal plans and implement them. It also showed that the designs and the results were inadequate and unsatisfactory. The services implemented in bustees were often found not to be in conformity with the existing trunk services, and therefore they could not function. The third experience was that because there was inadequate prior consultation, local civic authorities in many cases actively resisted taking over responsibility for the new installations, since they were neither organisationally ed, nor had the funds to manage. In some cases, lack of co-operation between the two sets of authorities led to installations such as septic tank latrines overflowing and becoming more hazardous than the service latrines they replaced.

The second phase of work attempted to integrate the improvement proposals and bring them into harmony at all levels — with the local residents, with the local authorities, and also by upgrading the surrounding trunk services. The steep cost escalation therefore partly reflects this attempt to achieve all of this with no change in the material standard of provision. Experience suggests that the new approach is more successful. For instance, local organisations and groups of residents are consulted about the location of services to be provided, and this has often resulted in point services (water, latrines) going inside clusters of living units (hutments) instead of simply somewhere along a pathway.

At a wider level, co-ordination is also taking place since 1977 with zonal committees, set up by the State government to represent local interests. Each ward is represented, thereby leading to the likelihood of better neighbourhood planning. Indeed, an important by-product of the programme has been the formation of local organisations. Because they have been called upon to express local interests, bustee residents have also taken up initiative in other areas, especially in adult education.

These, then, have been the benefits—a certain basic provision of environmental services, institutional learning, and (to some degree) local organisation. The costs are more complicated. Essentially, these arise out of contradictions and conflicts of interests. The improvements in the environment of slums, combined with the relatively stagnant economy in Calcutta and an ever-tighter housing supply, has made bustees acceptable to the lower-middle class. Moreover, owing to their relatively early formation, slums are excellently located in the city. As a result, both the land

Typical bustees before (left) and after Bustee Improvement Programme



Map of Calcutta showing location of bustees

and the rentable values of bustees have been rapidly rising. In some areas, there has been a 100 per cent rise from Rs. 20 to Rs. 25 per room, to Rs. 40 to Rs. 50 per room. The natural effect of this process, however gradual, is that the poor are being forced out of the bustees onto the pavements and to the formation of new squatter settlements. And in this sense, the Bustee Improvement Programme would seem to be failing at an essential level: the protection of rights. The market process is evidently more powerful than any legal or technical process.

This brings us to the question of motivating local improvement. Experience in many other projects in many parts of the world has established that tenure is perhaps the key factor for local investment and improvement in housing. In these terms, it is quite possible that the Bustee Improvement Programme is inadvertently undermining the tenancy, if not the tenure, of the largest resident sector in bustees. On the other hand, the likelihood of investment in bustees remains with the owners or the *thika* tenants of the land. The issue, therefore, is how to either induce (or force) the present landlords and *thika* tenants to make improvements, or alternatively, to empower the residents to take steps. The Calcutta situation, however, has so far not yielded solutions in these areas. Although the approach has been considered, it has not been tried because of: (i) expected difficulties in acquisition (on account of legal issues) and of heavy costs, and (ii) the costs and contradictions of the restructuring process.

There is another obstacle to a tenure solution. Firstly in a Calcutta bustee, there are, on an average, three to four tenants in a hutment, each hutment covering approximately 35 square metres. Evidently, this is difficult to divide. Secondly, to achieve this distribution, it has been calculated that 30 per cent or more demolition would be required—meaning a large loss of housing stock and a demand for substantial reinvestment. Thirdly, the cost of acquisition of land and of rebuilding huts as well as of current improvements, has been calculated to be roughly four times the current cost, jumping from Rs. 400 per capita to Rs. 1,600 per capita; or from Rs. 1.6 lakhs per acre to Rs. 6.5 lakhs per acre. Finally, there is a question of principle—to whose benefit is this huge capital investment? Absentee landlords will gain some 65 per cent of this amount and this will also constitute a massive blockage of capital usable elsewhere.

The tenure solution is therefore not promising, at least given current legal and financial provisions. But beyond these reasons, the Calcutta experience suggests that tenure cannot necessarily be regarded as a uniform answer. The social, occupational and especially ethnic heterogeneity of bustee communities has also shown that there are wide conflicts and few commonalities of interest, and uniform policies are not relevant. All indications are that those ethnic groups that have strong ties with their villages—and this is a very prevalent pattern, especially among Biharis in Calcutta—will not be interested in investing in urban areas, especially in bustees which they use only as a base for their activities. Other strategies, of a more complex nature, anticipating the heterogeneity of lifestyles and activities in the metropolitan area, are needed—strategies which can provide incentive and choice. And ultimately, the general problem must be recognised: despite normal expectations, the Bustee Improvement Programme does not address people of the lowest income levels. On the contrary, there is much to suggest that the programme has aggravated their situation. For their needs, the field is still wide open, and the questions unasked.

DILIP K. ROY

JAI SEN

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DELHI SQUATTERS RESETTLEMENT PROJECT

THE SUMMER of 1976 saw the largest forced resettlement of the urban poor in modern times. Over a period of eight months, nearly seven lakh people, almost the entire squatter population of Delhi, were shifted to resettlement camps as much as 30 km from the capital.

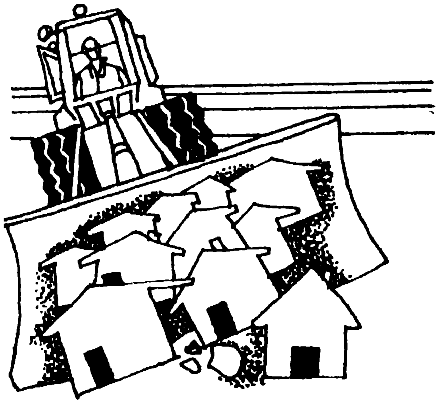
The Delhi Development Authority (DDA), which executed the entire operation, spoke of it in glowing terms. Their justification for the programme was: "The urban poor live in dilapidated settlements (and) in their tattered misery they mock the aspirations of all those who yearn to make cities sophisticated and modern. Furthermore, these human beings are unwelcome because they build shacks on urban land to which they have no legal right. It is only in the context of this magnitude and complexity of the problem that the Delhi Squatters Resettlement Project (DSRP) can be understood."

The argument is familiar. Squatters have tended to be viewed as problem populations by both western and Third World planners. They have been portrayed as posing political, social, economic and physical problems to the efficient operation of government and thus hindering economic development. To quote the well-known development economist Barbara Ward: "All over the world, often long in advance of effective industrialisation, the unskilled poor are streaming away from subsistence agriculture to exchange the squalor of rural poverty for the even deeper miseries of the shanty towns that, year by year, grow inexorably on the fringes of the developing cities. They are the core of local despair and disaffection .... swelling the urban mobs of Rio, voting communist in the ghastly alleys of Calcutta, everywhere undermining the all too frail structure of public order and thus retarding economic development that alone can help their plight."

The efforts of many governments to eliminate these "blockages" to development through programmes of largescale or smallscale squatter removal are therefore not surprising. And as the then vice-chairman of the DDA said, "The task carried out by the DDA — its magnitude, dimension and time taken to complete it — has no parallel even in advanced countries" What was the result?

Of the 27 camps that were set up for the displaced squatters, Daskshinpuri was one of the better located ones. A sand and dust wilderness before 5,000 people were moved in, it was divided into 16 blocks, each with 450 to 650 units. In one block, all the 100 families I spoke to had at least one adult member sterilised—the price for being allotted a plot in a prized colony that was only 15 km from Delhi.

Dipakchand was one such person. He had to present a family planning card, a ration card, a rent card and a demolition certificate (saying that his house in Delhi had indeed been demolished) before he was allotted a plot. But when he came to claim his plot, he found it was already occupied by another family. It was a widespread problem in the prized colonies. Sometimes as many as four families were allotted one plot of land and left to fight it out among themselves, or to bribe the local official, or secure the plot by promising to support the local ruling party politician.



The DDA had claimed that it had spent Rs. 27 crores to provide amenities to the 27 resettlement colonies. At Dakshinpuri, as in other colonies, the results of this expenditure were difficult to see even in March 1977, over six months after people had been herded there. Bright yellow boards announced the locations of non-existent schools, cinemas, parks, hospitals and shops, but only a few cows grazed on the barren land. For water, Dakshinpuri residents had one hand pump for 100 families, which managed at best to draw a bitter, muddy brew from the water-logged soil. The lucky ones were those who managed to fight their way to the three water tankers that rolled in every day to serve the 75,000 people. As a result, malaria and stomach infection were rampant. The number of people who died of disease in the first few months after resettlement has not been fully documented, but in Dakshinpuri alone the number must run into hundreds.

This brings out in its most extreme form the perverse nature of how the squatters are viewed. After being bulldozed out of their homes, they are dumped on so-called developed land outside the city. Their home is now a 25 square metre plot of land on which they are ordered to build their homes. The DDA specifications of a permissible house were, "One room covered by a roof, one window and space for a bathroom inside. No *kutcha* structures allowed." Raising the Rs.4,500 for such a structure was not the DDA's problem. And this in a situation where the poor have no legal guarantee that they will not be bulldozed away again.

John Dayal and Ajoy Bose, in their book, *Delhi under Emergency*, document the case of Mangal Das, a peon in a South Delhi office, who was shifted to Khichripur, a resettlement camp that was 25 km from his office. At first Mangal Das tried cycling to and from his office. But 50 km of pedalling every day brought racking pains to his legs at night. He was forced to take leave almost every second day and in the end lost his job. There were others, intrepid enough to continue making the journey, but six hours a day and one-fourth of the salary just for travel, was not an uncommon phenomenon.

The tales of needless suffering can be repeated hundreds of thousands of times over, but the DSRP affected existing communities of squatters in other ways as well. This forced resettlement broke up existing communities. Residents of one area, who had known each other for years, were scattered over many of the new colonies. Some remarks made by DDA officials lead one to believe that this was part of a deliberate policy. The internal organisation and leadership of the poor was destroyed. To the barren surroundings was added a barren social life.

Also, in a situation where the signature of an official is required even to pay your rent, people are forced into becoming totally dependent on official patronage and official mercy. And extreme conditions of dependency makes repression easy (for example, getting sterilised to get a plot).

Finally, one can ask who benefited from this attempt to beautify Delhi. With their access to employment in Delhi destroyed or greatly reduced, the residents of these resettlement colonies are willing to work at any wage if they can find work nearby. This suits the few factories that have come up near these colonies, since they have access to the cheapest labour force in the region.

S. K. DAS

Mr. Das is an architect in Bombay.

CHOICE—AN ALTERNATIVE APPROACH

DESPITE the work going on in various parts of India and abroad, it can perhaps be said that few effective approaches have been developed to meet the challenge of low-income housing. In this situation, a housing project during 1974-77 with a refugee community near Calcutta provided some useful lessons in low-cost housing in community development, and on the role of social work in development. These lessons can perhaps be modified and fruitfully applied in other contexts, to other groups of low-income families.

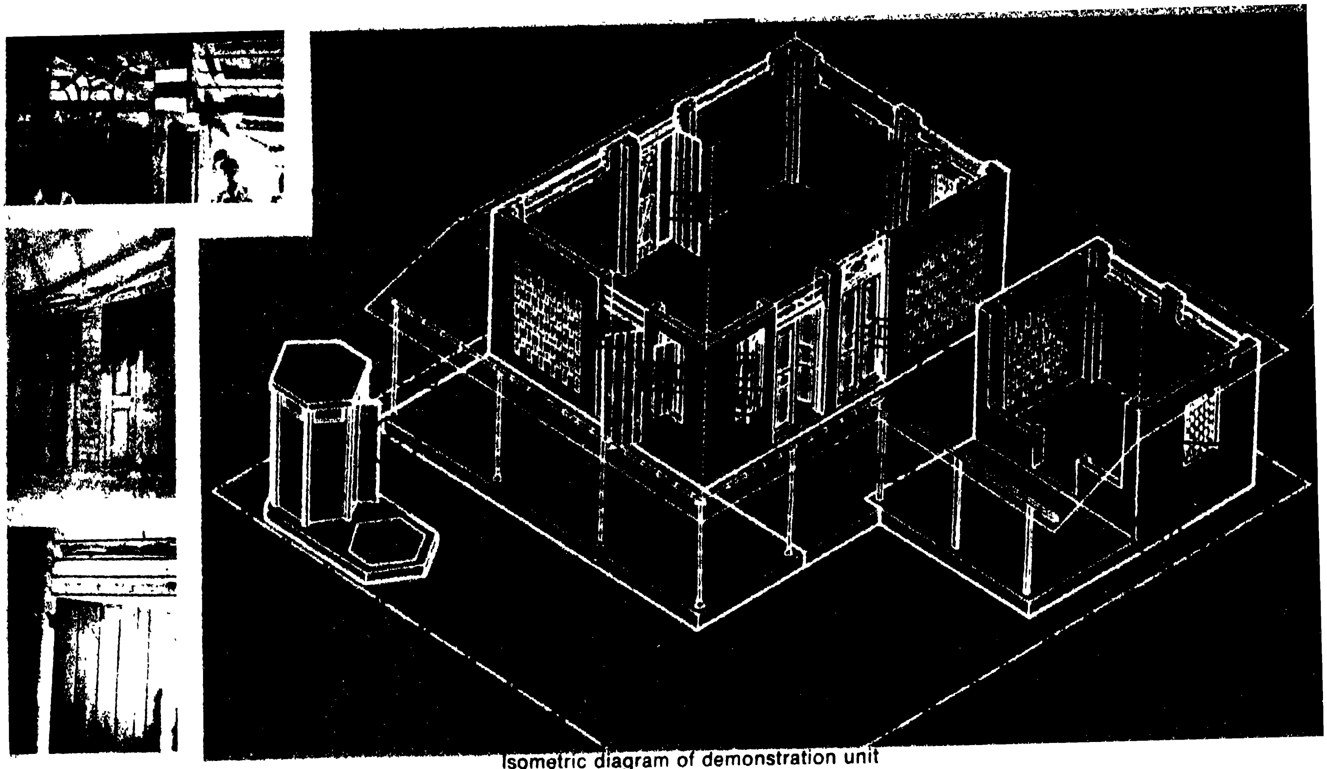
The project was originally initiated in 1973 by social work agencies, with the specific objective of building houses for each of the 119 families in a refugee colony on a budget of around Rs. 4,000 per household. Each family had been allotted a 167-square-metre plot as part of a State government rehabilitation scheme. The experiment in question was an attempt to : (i) design a housing system which could effectively meet the needs of individual families and yet cost lower than conventional 'low-cost' techniques; and (ii) evolve a field approach which used the planning and housing work as a vehicle for community organisation and development.

This type of approach requires extensive preparatory research and participatory planning. And it is essential to involve the community, which cannot take place without their trust and belief that the project will indeed serve their needs.

Participatory design and choice

Because, of the freedom initially extended by the agencies sponsoring the project, it was possible to research the lifestyles and housing preferences of families. This helped us design, together with the families, a housing system which would allow a wide range of their expressed needs to be met; in other words, a system based on choice. A 'kit-of-parts' housing system was designed; each part had a range of specifications and, therefore, a range of price tags.

A demonstration house was built in October 1976 to display the parts available : four different doors, four windows, three floors, two walls, three roofs, and so on, and also rooms of different sizes and orientations. A 'Housing Choice Manual' helped



Isometric diagram of demonstration unit

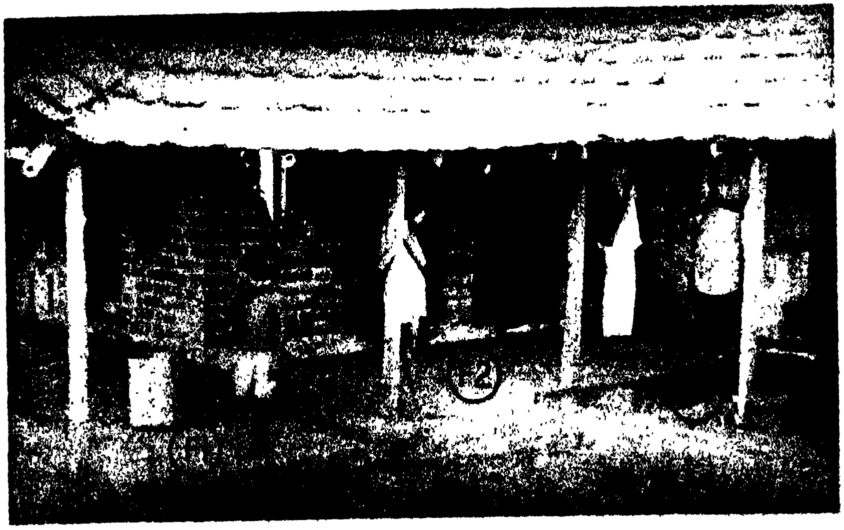
Spaces: MR1—main room, T2—septic tank toilet; V1 and V2—verandahs, ER1—extra room with verandah. *Floors.* F1—cement plaster on flat brick soling: F2—bricks on edge; F3—IPS on 7.5-cm concrete *Walls.* W1—12.5-cm new brick with 25-cm columns, bare-faced and flush pointed, W2—12.5-cm salvage brick with 25-cm columns with cement plaster on both sides; W3—bamboo posts; W4—salwood posts. *Doors:* D1—frameless hardwood Z-batten door; D2—hardwood Z-batten door and frame, D3—Bhutan teak panel door, sal frame; D4—teak panel door. *Wall windows.* WW1—brick jali, WW2—cement jali; WW3—swivel shutter, WW4—frame and batten shutter, WW5—frame and louvre shutter. *Fan light windows:* FW1—horizontal bars only; FW2—swivel shutter and bar; FW3—decorative grill. *Main roof structure* (not shown): Raniganj tiles. *Verandah roof structure:* VR1—bamboo frame; VR2—hardwood frame

families to decide their total budget (in terms of aid, cash and any materials they may have had or could obtain), and then to choose the parts, according to their budget. Based on the permutation a family chose, the plan of its individual house was drawn, and the family would then be responsible for individually hiring *mistris* and getting its house built, with the help of a site supervisor provided by the project. Self-supervision is a large cost-saver, besides ensuring quality.

One central advantage of this system is that for a standard budget, say Rs.4,000, one can have several designs. For instance, a growing young family can choose parts which make up a house with a large area but lower specifications, which they can gradually upgrade over time, as income improves. Similarly, an old childless couple can choose a small but high specification house, adequate for their needs and requiring little maintenance and upgrading. It is also possible to plan for space for a cottage industry, for keeping cattle or for renting out. Moreover, the system permits families to add to a standard budget, in cash, materials or labour, or even to renovate their existing *kutcha* buildings to *pukka* specifications.

In constructional terms, the economics of this system add up to more than 30 per cent saving over conventional techniques. For instance, even allowing that Calcutta has among the highest cost of construction and material in the country, it was possible to build a detached bungalow house of *pukka* specifications at a rate of Rs. 132 per square metre of plinth area (as of November 1976). For Rs. 4,400, one obtains one room, 3.75 X 5.05 metres, plus a verandah, 1.83 metres wide and 5.32 metres long, with foundations for two storeys, *pukka* walls and floor, and a saalwood truss and tile roof, equipped with doors and windows and an individual septic tank latrine. This cost can be reduced to Rs. 105 per square metre if certain inessential and expensive items like framed doors and windows are replaced by traditional details, and the *pukka* cement floor by mud. In other projects, the savings could be much more if the house form is changed to semi-detached or row housing. These costs do not mean a compromise in specifications or qual-

Demonstration unit showing floors under construction



levels of construction and supervision.

The experience of the experiment suggests that this type of housing process can be applied in other contexts if the following three essential features are accepted.

(i) It is based on choice—in materials, specifications, finishes, plans and sizes. To these, in other projects, should be added methods of financing, relationship to land (tenant, free-holder, etc) and level of infrastructure services. The result will be that each family can effectively design for itself the house that it wants, can afford, and will meet its future needs.

(ii) It is based on *involvement*. Families, and the community collectively, are fully involved in decision-making, planning, design, and construction. This process leads to education and a greater awareness, as well as better housing.

(iii) It is *culture and situation-specific*. The house system was designed in response to the expressed needs of low and lower middle income Bengali refugee families. This means that although the system described here can be used fairly directly for other refugee communities in similar situations, it is not directly relevant to the needs of people from other backgrounds or situations. By following the same steps, however, one can design a manual for new contexts.

This last point needs to be emphasised. The project experience suggested that each culture and ethnic group has its own vernacular in dwelling, and in the long and short runs, it is most economic to design for the lifestyle of the users. For instance, the project saw the introduction, halfway through the design process, of the 25-cm brick column instead of the 12.5-cm folded plate wall design adopted earlier. This was done because we realised the aspirations of families to ultimately build a second with heavy furniture, which requires columns below for support.

Housing versus development

The concrete results of the experiment, however, have not till now been housing in its technical dimensions, but rather development in the form of a number of housing-related or housing-generated functions. Even though a set of ideas had been evolved over nearly three years by 1977, and the design of the housing system, construction of the demonstration unit, preparation of estimates, specifications and the family choice manual had been completed, the social work agency in charge of the project decided not to go ahead with the work. The reasons for this withdrawal were never made clear, but, for a student of developmental housing, the turn in the experiment also revealed various lessons, which can be summarised as follows.

(i) Such housing—housing by people—cannot be contained within a technical frame but must take into account the other interrelated actions which are a part of housing and settlement, especially social and social-political cohesion and organisation, and action for income upgrading. Any agency sponsoring such projects must accept this broader framework, and indeed should work to encourage its emergence.

(ii) There are latent and intrinsic conflicts and contradictions between the various parties or groups involved in any process of human exchange, and though these may only be exposed in time (if ever), they play a powerful role at all times (in this project, broadly speaking, there were four parties—the community, the social work agencies, the State Government Rehabilitation Department, and the author-designer).

(iii) Charity-based development is ultimately overwhelmed by the fact retaining a strong advantage in remaining in control of the important decisions, and with the receivers having an extremely difficult choice to make—whether to accept or to reject.

Demonstration unit, now being used as a community centre

(iv) The logic of such a relationship cannot be resisted unless it is ensured that the receivers also, during and by virtue of the process, come to vest interest in the process in concrete, material terms (for instance, financial commitment or a stake such as benefit of labour wages) *or* develop an understanding of the contradictions in interest. The tentative argument here is that the former will give rise to the latter in a time of real conflict.

The housing units ultimately started, in 1979, are of a different nature from the system developed; they have a standard design and regimented layout. No choice remains open to the receiver, except whether to accept or reject the gift of the Rs. 4,000 house. Each family will now have to follow the path set by institutional housing and fit their needs to the box they are given.

This turn of events can be taken as symbolic of the conflict between the perceptions and interests of the different actors. Whereas the social work agencies had sponsored the project as a means of aiding low-income families, the actual process encountered opened up a far wider range of issues than they had perhaps expected—for instance, what individual families would do with the Rs. 4,000 'gift' they were getting, and what the buildings would look like. Though the issues of financial control and aesthetics may seem far apart, they boil down to the same thing : the housing system, in its final form, took all control out of the hands of the institution, and placed it in the hands of the families. As such, there was no real say that the agency would have in how the families used the money.

On the other hand, the idea of choice opened up a wide horizon of new possibilities. For example, soon after the early decision that not all houses need be alike; came the idea that houses could also include space for income-enhancement. This process culminated in a proposal to the agency that families be permitted to use a maximum of 50 per cent of their 'gift' of Rs. 4,000 (again, their discretion) as collateral for a loan for starting or expanding their trade or business, and only the remainder for actual housing. This was a feasible split since the housing manual showed that a minimum of Rs. 2,000 was adequate to rebuild in bricks and mortar their existing houses. For many families, therefore, the *balance* Rs. 2,000 was an easy opportunity for collateral that they would probably never again see in their lives. But it was, quite possibly, also this kind of proposal that led to the total set of possibilities being summarily rejected by the agency.

The choice process had some practical results as well. A small number of people, on the sheer strength of the ideas being circulated, got into business or trade—buying goats, making readymade garments, opening shops and entering the hawking trade. A number of schemes, such as manufacturing ampoules for distilled water, were designed. A *mahila samiti* (women's committee) was formed, which for quite a while used the demonstration-unit-turned-community-centre for learning sewing and producing readymade garments. A community health scheme was mooted; a small co-operative fishery was established. Years of animosity between two rival groups was, for a while at least, overcome by the process of forming a community-wide *samiti* with an elected council, and the attempt by a government urban development agency to appropriate a part of the colony for a major new road was successfully resisted.

Electing the Housing Committee

What is housing?

This article has tried to present an experience and an idea. Housing is one of the vital actions of life, one of everyone's basic needs. The experiment was an attempt to let families find out what their needs were, and then to design together a process of meeting them within given constraints. It was also, technically, a search for a design concept and a system which could accommodate and respond to the cultural aspirations of the people at an affordable cost. And [illegible]s an effort to use all these processes of planning and housing as a vehicle of community organisation and development.

The question that remains is whether the experiment was successful or not. Common sense gives an obvious first answer—that there is no one answer, and any answer will depend on the perceptions and interests of the person answering. Each participant in the process belongs to an interest group—whether it is the families involved, the community leaders, the sponsors, or the designer. Their answers will rarely be the same.

The author-designer's answer, however, can be given. The experiment showed that the approach taken was a powerful generator of community involvement and action as well as an effective method of designing a culturally appropriate and cost-effective housing system. It also tended to confirm that a fairly sophisticated housing system can be designed together with relatively 'uneducated' people. The development of ideas and action during the period revealed housing as a vital force and process in people's lives. The concept of choice grew with the realisation of the natural interdependence in people's minds of shelter, income, marriage and other social and political structures. Subsequent work, which has tried to build on the project by consciously understanding and designing objectives and methods, has shown that the approach adopted was naive in many ways and that there is still plenty of ground to cover. But it has also confirmed that there is much potential in the approach.

JAI SEN

INDIGENOUS TECHNOLOGY IN KERALA

"WHEN you look at a traditional building or a bit of vernacular architecture anywhere, you are looking at results, literally, of thousands of years of research on how to deal with local materials, conditions of living, cultural patterns, climate, geology, fauna and flora and everything else. So it is quite stupid just to ignore what you see," says an architect who has become the centre of a controversy for practising exactly what he preaches. The architect is Laurie Baker, an Englishman living in India for over 30 years and now the most vocal spokesman for rediscovering the values of our traditional building techniques.

Baker draws heavily on the indigenous building tradition in Kerala, where he has been living for the past 10 years. By designing and building houses that cost half or less of what a house of similar area built by a contractor or the State PWD would cost, he is by implication hurling an accusation of wastefulness and incompetence at conventional building practitioners. In turn, this generates a fierce opposition to his work, and his many critics point out that Baker's houses are not durable, they often leak, and have a short life. Baker counters by maintaining that we have no right to impose our ideas on future

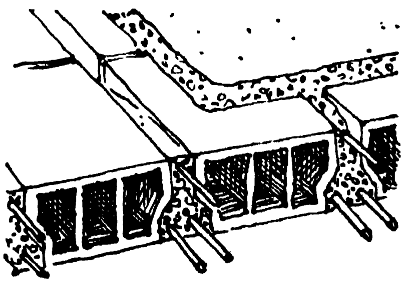
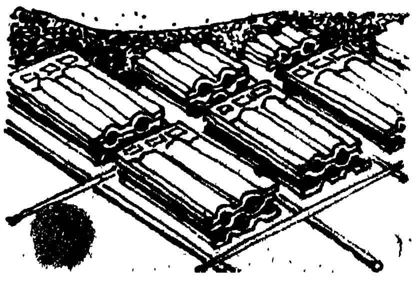


Fig.1 (above) Roof made with hollow clay tiles on RCC beam and (below) RCC filler slab using reject Mangalore tiles as fillers



ouses that will last for over a hundred years and that the houses can be made more durable over the years if the residents want them to be so.

Yet his work is important—not only because it shows us how to cut costs substantially, but also because Baker seems to be able to select what is important and essential in both traditional and modern techniques and materials to design a dwelling that is comfortable and in harmony with its surroundings. His commissions include the Centre for Development Studies (CDS), Trivandrum, low-cost houses for a fishermen's village in Kerala, and recently, a UP government-sponsored project for building lakhs of houses for landless labourers in UP.

The buildings in the CDS campus, with a total plinth area of over 6,500 square metres, were built for less than Rs. 1.6 million. The CDS campus has been highly praised, though not the low-cost houses in the fishermen's village. The residents there complain that the plinth is too low, the houses get unbearably hot in summer, and that they are not burglar-proof. Baker himself is reportedly piqued that though the houses were designed by him, the work was undertaken by the State PWD and he could play no role in its supervision.

Baker's basic cost-cutting philosophy seems to be that if any conventional building practice is not essential to the house, do without it, and if a local material or design has proved its usefulness, use it rather than the costlier modern materials. This leads to some startlingly simple innovations, as are classified in the Report of the Expert Committee (of which Baker was a member) on "Performance approach to cost reduction in building construction" prepared for the Government of Kerala in 1974. The report highlights many of Baker's ideas in its recommendations, and these are worth reproducing in some detail, even though the recommendations are specific to Kerala. The Committee recommended, among other things, that:

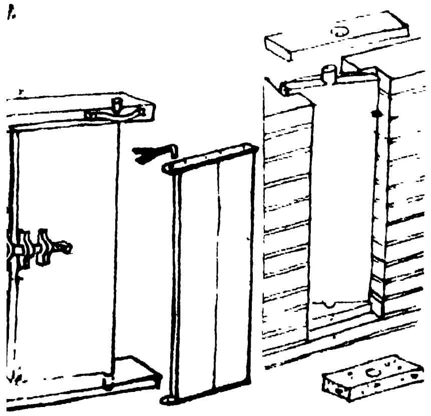


Fig.2 Frameless doors with old style shutter (left) and frameless country wood window (right)

Fig.3 Opening in wall having bricks placed on top of each other in such a way that there is no need for an RCC lintel

For all masonry construction, lime-surkhi mortar should be used.

There is rarely any functional need for plastering walls, but where walls have to be plastered, lime-surkhi mortar should be used.

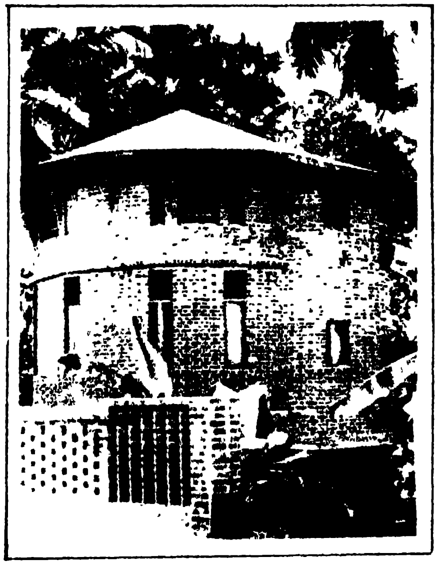


Fig 4 A house in Kerala designed by Laurie Baker showing unplastered outer walls and country wood windows

In the design of buildings, full use should be made of the strength of brick work considered as a three-dimensional system, as permitted by the National Building Code.

Walls, 11.25-cm thick, when properly designed, meet the requirements of the National Building Code, especially for single-storey buildings.

Even with the proposed use of metric bricks, load-bearing half brick walls will be possible, provided the number of folds and piers are adjusted.

Many windows in a house are seldom closed and these can profitably be replaced by brick jali walls.

Windows which need to be closed can be designed to minimise the need for lintels.

When required, lintel designs should be rationalised, as conventional lintels are over-designed.

Doors can often be frameless. Where frames are desired, the present concrete frame is cheaper than the normal timber frame.

A number of country woods such as mango, maruthu, etc after preservative treatment, can replace comparatively expensive conventional timbers.

Mangalore tile roofs should be used wherever possible. Otherwise, reinforced concrete filler slabs should be used. The fillers can be low quality Mangalore tiles, commonly used hourdis (hollow clay tiles) or special hourdis. The beams can be precast or cast in situ.

The use of such systems should be made mandatory, especially for the public construction programme. The use of currently prevalent reinforced concrete slabs should be considered only under special circumstances.

Except for heavy duty floors, the use of the concrete base can be replaced by a brick-bat base paving. The usual surfacing of cement plaster should be replaced with lime-surkhi or lime-cement combination plaster.

The traditional use of burnt clay tile floor surface is still within low-cost limits. Costs of terazzo (mosaic) flooring can be reduced by eliminating white cement, stains, oxides, marble powder, etc and by making use of grindable natural coloured stones with grey cement or brown pozzolana cement.

These recommendations have to be seen in the context of the Committee's categorical statement that, "The time has come for a strong campaign towards simple and comparatively less expensive buildings for all. We decry any move towards low-cost housing for 'the poor'. Reform, thinking, re-planning and re-designing must start at the top and spread through all strata of society." Is this too much to expect in the present Indian context?

YA

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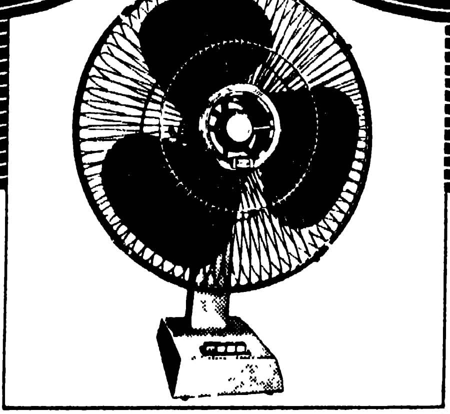

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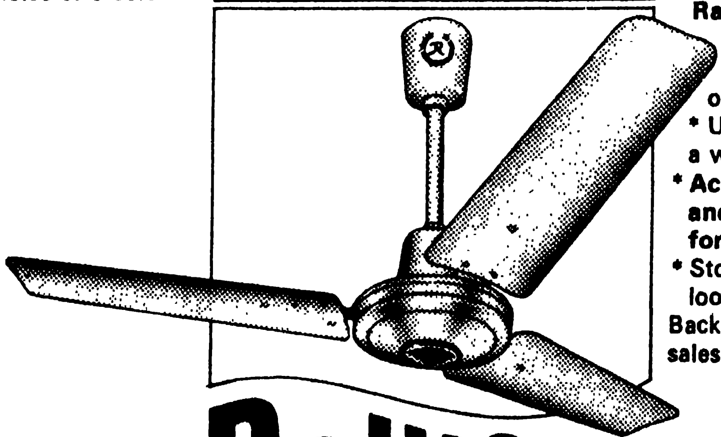

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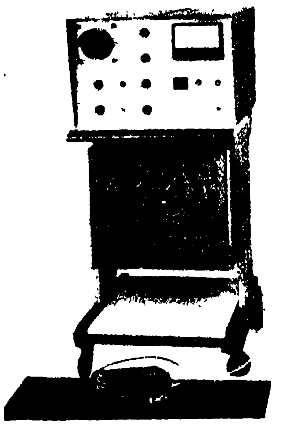
Surge comparison tester

IT IS very difficult to fully test the electric windings of motors and transformers to detect every abnormality. Normal tests such as those for winding resistance or insulation resistance have very limited uses. For example, the winding resistance test is not sensitive enough to detect turn-to-turn short circuits. The insulation resistance test also cannot detect such a fault as it measures the insulation resistance of the winding as a whole with respect to the motor or transformer body, and not between different turns of the winding.

The surge comparison tester (Model ST 79) developed by the Electronics Corporation of India Ltd (ECIL) should meet a long-felt need for versatile non-destructive test equipment which can test the healthiness of electric windings of motors and transformers on completed units.


Surge comparison tester for non-destructive testing of single- and three-phase electrical windings

The principle of surge comparison has been used in the tester. The tester generates two electric high voltage pulses simultaneously. One pulse is applied to the winding under test and the other to an identical winding which is known to be healthy. The oscillatory decay of these pulses is monitored on cathode ray tube display. If the winding under test is healthy, the two waveforms are indistinguishable. Any variation in the two waveforms indicates a deviation which should be analysed. The type of deviation gives an indication of the type of fault. Such a test method is very sensitive and an excellent means for quality control in manufactures.

The tester has a second position, where a much reduced surge can be applied to adjacent segments in a DC motor, that is, small parts of a winding can also be tested.

The tester has these specifications: Output—surge frequency, 50 Hz; typical surge duration, 3 to 300 micro seconds. Position 1—maximum surge output voltage, 10 kV; maximum surge energy, 7.3 Joules. Maximum instantaneous current, 100 amps. Position II—maximum surge output voltage, 1000 V; maximum surge energy, 0.25 Joules. Display—cathode ray tube, 12.7 cm with graduated green filter.

The tester is supplied as a self-contained unit mounted on a trolley and designed to operate from a standard 230V AC 50 Hz single phase power supply. If the product has the extremely high reliability which is expected of a test equipment, it should find extensive use.

V. N. MANOHAR

Mr. Manohar is a consulting engineer (electrical) with Tata Consulting Engineers, Bombay

Hydrogen production from coal

HYDROGEN, which is the most important raw material for the production of ammonia, and hence for urea and nitric acid, is presently produced from hydrocarbons. With the diminishing hydrocarbon resources and constant upward price revision, it has become necessary to look for alternatives. The next important source could be hydrolysis of water using nuclear energy. But because of problems in the enrichment of the useful isotope at an economic cost and associated environmental hazards, exploitation of nuclear energy at a low cost is still a distant possibility.

The world has another abundant resource—fossil coal, though it has its own problems of recovery and use. Invariably, the ash content in coal is high and the associated sulphur makes utilisation more expensive. Production of power from coal by the thermal process is an unreasonably inefficient process (energy conversion, at best, of 25 per cent), though it is being used extensively the world over.

A recent process describes the electrochemical oxidation of coal slurry at temperatures of the order of 100° C, using a DC voltage as low as 0.8 to 1 volt. The net reaction of oxidation is believed to be:

$$C(s)+2H_2O(l)\rightarrow 2H_2+CO_2$$

Conventional production of hydrogen from coal uses steam-carbon reaction to produce synthesis gas ($CO+H_2$) by a strongly endothermic reaction which must be conducted at about 800° C to ensure a favourable equilibrium. Synthesis gas is then purified to remove sulphur compounds and other impurities followed by reaction with water to shift the CO/H_2 ratio as required. The reactions are:

$$\begin{array}{c} C+H_2O\rightarrow CO+H_2 \\ CO+H_2O\rightarrow CO_2+H_2 \\ \hline C+2H_2O\rightarrow CO_2+2H_2 \end{array}$$

The electrochemical gasification process produces a pure stream of carbon dioxide at the anode and hydrogen at the cathode. Thus the need to separate the complex gas mixture of H_2, CO, CO_2, H_2O and sulphur compounds in the conventional coal gasification process is eliminated.

The following conditions are used in the electrochemical oxidation: 3.7 molar H_2SO_4, coal slurry concentration 0.475 g per cc, particle size 250 microns or less, and temperature 23°C. During oxidation, partially oxygenated compounds are formed on the surface of the carbon particle containing groups such as -COOH and -OH. These retard the oxidation rate. It has been observed that if coal is recovered at this stage and heated at about 200°C, so as to volatalise these products, the regenerated coal produces the same reaction rate as the fresh coal. The reactivity could also be restored by extracting the surface compunds with organic solvents such as acetone. (The exact nature and concentration of these intermediates have not been reported. It is felt that these could form a very useful starting material for some important chemicals such as phenol and its derivatives, aliphatic hydrocarbons and carboxylic acids.) Some electrolyte-soluble oxygenated compounds are also produced as indicated by the organic carbon assay of the filtered electrolyte after extended anodic oxidation of coal. Products which are neither isolated nor identified are likely to be partially oxygenated compounds containing groups such as -COOH, -OH, $-CH_2OH$ and -CHO. These compounds may be eliminated and a continuous reaction obtained if temperature of the order of 200°C is used. Of course, a high pressure corresponding to this temperature would be essential for oxidation.

A mass spectrometric analysis of the gases produced at the anode and the cathode indicated total absence of SO_2 or H_2S, though the parent lignite coal contained a significant amount of sulphur.

The efficiency of the process is comparable with ordinary water electrolysis. In water electrolysis, the energy required to split the water molecule is supplied solely by electricity, whereas in this process, it is supplied partly by electricity with the balance coming by way of concomitant anodic oxidation of coal. Whether this process can also convert materials like cellulose and other natural organic materials to hydrogen remains to be seen.

V.C. MALSHE

Dr. Malshe is a research officer at the ACC Research Centre, Bombay.

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Good for Indian conditions

Television Engineering by Arvind M. Dhake, Tata-McGraw Hill, New Delhi, 1979, 476 pp, Rs 30.

WITH THE development of a TV network in India television engineering is being taught in many colleges. In addition, a large number of TV technicians are engaged in servicing sets. Prof. Dhake's book aims at meeting the requirements of these students and technicians.

The book is based on the Grade B standard for service, adopted in India for technical reasons. This standard is the same as adopted in West Germany. However, the standards in the USA and Britain are different—grades M and A, respectively. The number of scanning lines are different for the different grades. The number of picture frames per second depend, upon the power supply frequency in a particular country, and correspondingly, this is different for each grade of service. Also, there are other differences such as modulation, channel spacing, etc. The book under review has listed seven different standards of black and white TV services currently adopted in different countries. While the principles of television are the same everywhere, the practical details are different for the different standards. These details (which can confuse a beginner while applying the principles learnt by him to practical problems) constitute one of the serious disadvantages of using many standard American or British books on television.

Over the last 15 years, colour television has been introduced in many countries. Hand in hand there have also been great strides in solid state technology. Thus modern books which give a detailed treatment of solid state circuits also emphasise on colour TV with the result that books giving exhaustive treatment of monochrome solid state TV sets are not commonly available.

Yet another differences between TV in India and abroad is that we have only one TV station giving primary services at a place, whereas several stations operate at a place in other countries making multichannel reception possible. The antenna systems are therefore different.

With all these aspects characterising our TV network, students and teachers in India have been looking for a good book on the subject, specifically written to suit our conditions. *Television Engineering* is intended to meet this requirement.

The book lays great emphasis on TV receiver circuits. In this respect it may be compared with Grob's *Basic Television Principles and Servicing* (McGraw Hill, 1975), which contains one chapter on camera tubes but does not deal with other topics related to TV signal transmission. The book under review devotes about three chapters, comprising over 75 pages, to these topics, which will be useful for any person interested in television in its entirety. The book also meets the requirement of the usual syllabus for degree and diploma students. And since its price is reasonable, it is expected to become popular as a textbook soon.

On the receiver side, the treatment, although concise, is adequate and suitable for the level of an undergraduate engineering student. The author has gone into some details of design of circuits. Grob's book, on the other hand, is aimed at service technicians. It would therefore be worthwhile for students to use Dhake's book as the first text and then go on to Grob's book to understand the detailed analysis of servicing aspects.

Grob's book has one special feature. There are several illustrations of distorted TV images which arise due to fault, conditions in the circuits. Each chapter includes a few illustrations of this type pertaining to the circuit discussed. After reading Grob, one is therefore able to locate the fault to the particular stage by looking at the image distortion. The utility of Prof. Dhake's book would be enhanced if similar illustrations are included in the next edition.

P. J. JOGLEKAR

Dr. Joglekar, an electronics consultant in Bombay, was formerly with the Indian Institute of Technology, Delhi, and the Regional Engineering College, Tiruchirapalli, Tamil Nadu.

Not for self-study, please

Principles of Plasma Mechanics by B. Chakraborty, Wiley Eastern, New Delhi, 1978, 410 pp, Rs 21.25.

THE BOOK which grew out of a course given by the author at Jadhavpur University contains twelve chapters that deal with basic electricity and magnetism; dynamics of charged particles; basic plasma properties; magnetohydrodynamics; applications of magnetohydrodynamics; collision process in plasma; ionospheric cross modulation theory; kinetic theory; distributions in the six-dimensional phase space; plasma kinetic theory; small amplitude waves in plasma; and, lastly, some relativistic and other non-linear aspects of plasma.

While attempting to cover basic plasma physics in a reasonably sized textbook, a better choice of material could have been made. With excellent books already available in electromagnetic theory, the first chapter seems superfluous and the discussion on non-linear problems—especially the work of Nishikawa—could have been more extensive instead. There is no mention of the quasi-linear theory, and the chapter on cross modulation in the ionosphere does not fit in with the general scheme of the book. There is hardly any problem which can be used by the student to test his understanding of the subject.

The author seems to have taken pains to refer to various original sources in the preparation of the book, but its usefulness becomes limited because of errors in basic derivations. Take, for instance, the derivation of the dispersion relation for the ion acoustic wave (p.75). The assumption that the frequency of ion acoustic wave $\omega \gg \omega_{pi}$ is not valid although the final dispersion relation is correct. Though implied, it has not been stressed that, in the electron motion, the electron inertial term is negligible for low frequencies. Again, in the chapter on kinetic theory, the probabilistic interpretation of Dn(Z) (p.229) has not been given. As a result, relation 4.2, although correct, appears unjustified.

The appendix on delta function (p.399) calls for some improvement. Here are few examples of vague or incorrect statements in the book:

p.1: "... the current density and electric field intensity are usually found to be proportional in conductors."

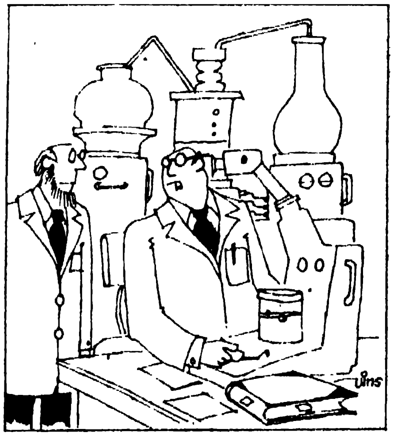
p.72: "In dielectrics ω is proportional to k and so there is no cut-off lower limit of ω."

p.74: "Also, in plasma ϵ depends on the frequency and in dielectric it is a material constant usually."

It is only with great care can a student use this book for a course in plasma physics, and it would be difficult to recommend it for self-study.

RAJU IYER

Dr. Iyer is with the Laser Section, Bhabha Atomic Research Centre, Bombay.



"Just remind me again, will you, is this research-oriented or award-oriented?"

Young scientists define their role

ABOUT 180 scientists, planners, administrators and activists interested in social change participated in a symposium in February where people from wide interdisciplinary interests discussed issues related to the totality of problems of science and its role in development, especially in the growth of a self-reliant nation. The four-day symposium on "Management of Indian Science for Development and Self-Reliance" was organised by the Society of Young Scientists (SYS) at the All-India Institute of Medical Sciences, New Delhi, from 6 to 9 February. Though part of the funds were acquired from governmental agencies like the Department of Science and Technology, the Council of Scientific and Industrial Research and Indian Councils of Medical and Agricultural Research, the entire effort was essentially voluntary and non-governmental in nature. The approach was not to merely criticise the system, but to arrive at some concrete proposals and a positive plan of action.

More than 90 papers read ranged from science policy, planning for development, rational utilisation of natural resources, and health care system to management of research in R and D institutions and the democratisation of the decision-making process at all levels. These issues were discussed in an effort to scientifically analyse the problems and seek solutions.

Since its inception five years ago, the SYS has been working to promote interaction among scientists themselves and with others in order to foster better science in our scientific institutions and to identify the role of science in improving the lot of the common man. In this process, the SYS envisaged a particular role for committed young scientists.

Today, science is an organised activity which has consistently grown in our country, primarily in the form of a constant growth of R and D institutions. The merits and demerits inherent in the process of institutionalisation have also grown concomitantly. While on the one hand this has generated a high degree of sophistication and a clan of expert scientists who acquire more and more knowledge to delve deeper into their chosen fields, on the other hand, it has often isolated these experts from people and their real problems. And because of centralisation of power to take decisions in a strictly bureaucratic manner, younger working scientists have most often been used like production assistants in a factory where they do not get an overall perspective in which they are working. Not only does this stunt their material growth, but it also stifles expression of their scientific talents. In such circumstances, science is managed rather than practised as a process in which independent enquiry may flourish.

This has serious implications. For, though the days of a solitary scientist working in isolation are gone, the basic tenets of scientific attitude are still the same: freedom of thought, expression and enquiry and an open exchange of ideas. But these are largely missing from our R and D institutions, and their output is far from satisfactory despite the large manpower involved and the reasonably large financial input.

Concepts and objectives

The frustration and concern of a large number of young scientists prompted the SYS to resolve these central questions. It, therefore, sought to initiate a process by which committed individuals and groups from research institutions and universities could be involved in working for the promotion of good science, which should contribute to national growth and development and whose benefits should reach those who need them most.

The symposium was the beginning of this long-term programme. The meeting had the following limited objectives: (a) expose young scientists to the key issues; (b) initiate detailed informal discussions with experienced people and inquisitive youngsters to form small working (action) groups which would take up specific projects (the mechanism of conducting these projects are to be evolved and guidelines for funding are to be discussed); and (c) continuous follow-up of the projects so that they spur the growth of more such groups as the SYS in different research institutions. Simultaneously, efforts are also to be made to co-ordinate the activities of the existing groups. These groups will continue the debate at institutional and regional levels and evolve mechanisms to influence decision-making at all levels through participation of younger scientists in the process.

Within the organisation, the SYS has maintained a combination of a democratic decision-making process through intense discussions based on hard facts, on the one hand, and an atmosphere of cordial informality on the other. This has helped in taking decisions with maximum participation of people even if with diagonally opposite viewpoints or ideologies. In order that this scientific attitude of taking decisions after intense informal discussions is followed, we tried to keep more time for discussions during the symposium than for formal reading of papers. To enable this, several parallel sessions on fairly co-ordinated topics were arranged, where the speakers confined themselves to the central theme and idea with data, if any. Reports of these discussions were presented in joint sessions and a debate on the total perspective of the issues was held during panel discussions at the end of the day.

Conclusions and plan of future action

Since not many speakers had done enough homework, opinions were expressed more as reactions than scientifically analysed facts. Nevertheless, it was felt that the discussions should end positively—not merely making recommendations for the government to bother about, but with a concrete plan of action for young scientists to follow up. *It was concluded that the young scientists must undertake systematic exercises on at least some concrete projects to begin with.*

As for the main topic, the young scientists questioned the model of development in post-independence India. There was general agreement on two points—that the present model was essentially a legacy of the colonial past, primarily serving the interest of the colonial powers, and that alternative models should be developed in all fields, health, agriculture, education, judiciary, industry, etc. It was decided to undertake projects on: (i) appropriate technology, (ii) health care alternatives, (iii) integration of medical systems, (iv) philosophy of science, and (v) democratisation and scientific methodology in institutions.

But first the grave distortions in our S and T policy and planning need to be studied in depth. And this is possible only through democratising the science policy planning process whereby organisations of young working scientists can find access to information concerning various areas.

In general, it was felt that the country's basic needs and the resources available to fulfil them have not been identified. Consider, for instance, the indiscriminate use of non-renewable resources; efforts should be made to switch to renewable indigenous resources. These, and the technology for their optimal utilisation, should be developed, keeping in mind the ecological balance. Particular references were made to the pressing problems of energy and agricultural byproducts. It was stressed that the masses should be educated on these issues. Detailed studies should also be made on the export of raw materials so that immediate measures are taken to stop their indiscriminate export.

Another issue discussed was the link between industry and research institutions. Neither does industry take its problems to research institutions and universities, nor does it use the available technology in our research laboratories. Instead, it prefers indiscriminate import of technology, which aids vested interests to make deep inroads into our economy and stifles the growth of our science and technology. Mechanisms should, therefore, be evolved to involve scientists in research in an area where import of a particular technology has been suggested. The importing agency should, on the other hand, be made to prove that the technology doesn't exist in the country or cannot be created within a stipulated period.

Meanwhile, industries should be encouraged to build closer links with research institutions and universities, update design and introduce new products rather than seek recourse to import of technology. It should be made obligatory on the part of both public and private sector industries to provide adequate funds for R and D. Some of the aspects that need to be studied here are: (i) rational utilisation of equipment, (ii) purpose and frequency of foreign travels by scientists, (iii) import of solar energy technology, (iv) export of edibles, (v) pozzolanic materials and their use in construction, and (vi) popularisation of science among people.

In the medical care system, the introduction of the Community Health Worker (CHW) Scheme was welcomed by consensus. But unless selection, training and continuous supervision are planned and executed with great care, the scheme is bound to fail. Besides, the CHW scheme should not be seen as an alternative, but should become a part of a larger mobilisation and reorientation of doctors, paramedical personnel, medicines and other inputs into rural areas. Also, medical problems cannot be isolated from aspects like providing safe drinking water, adequate food, etc to the rural poor. It is necessary, therefore, for doctors as well as planners to critically analyse various aspects of the medical system in depth and formulate an alternative policy. It was decided that young scientists should systematically document all the information available to enable a meaningful discussion on this topic.

Institutional structures

Practice of good science also depends on the structure of the R and D institutions and universities. The symposium recognised that the structure of these institutions, based on the colonial model, does not meet our present needs. Centralisation of decision-making power in the hands of a few leads to a hierarchical system where the atmosphere often does not encourage creativity. Concern was also expressed about the curtailment of democratic freedom and the vindictive attitude of authorities against democratic movements in R and D organisations whereby people have been arbitrarily victimised. Such victimisations should be vacated and freedom of expression and democratic rights should be guaranteed to scientists to acquire information related to science policy and development of the institution.

Besides, the group strongly felt that the system of Secret Reports (SR) and Confidential Reports (CR) should be scrapped. The progress reports of all persons should be made public at the end of each year. At present, several autonomous research institutions lack any mechanism by which scientific workers can get legal redress of their grievances. This anomaly should be immediately looked into so that scientific workers get their due natural justice.

Though the country has several centres of excellence, they have not made much impact on society in general. This, it was reasoned, was because of the lack of mass primary education. Mass primary education should, therefore, receive priority.

Science, and more so technology, is not neutral. But it has not been able to constructively influence our cultural and social values. Scientists should popularise scientific knowledge in regional languages. Efforts should also be made in the form of a movement to change the social-cultural and political values that oppress women within the scientific community.

A few other projects undertaken include: (i) identification and collection of information about groups working in different parts of the country which utilise S and T inputs for development and self-reliance through alternative approaches, (ii) study of excessive advertisement through mass media on use of drugs and allied materials resulting in its misuse, and (iii) mobilisation of public opinion against import of more than 200 MW transformers.

This is only an illustrative list of projects

(Contd. on p. 59)

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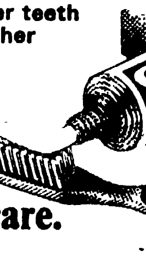

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...the earth lost its protective ozone screen

THE energetic ultraviolet rays from the sun would reach the earth's surface in abundance, ultimately, destroying all the vegetation on the earth. There will be climatic upheavals of unpredictable magnitude. The earth's surface will acquire many red zones but there will be no men to appreciate the beautiful red. No advanced form of animal life would survive on the earth except the benthic creatures below the protective layer of water.

Slow destruction of ozone would indeed be a miserable experience for hundreds of generations of man. Large scale blindness would be the first major human ailment. The fair-skinned people would be the earlier victims of skin cancer (melanoma) which will ultimately engulf large human populations. It is already one of the most rapidly increasing forms of skin cancer in the US. Darkening skin colours all over the globe will first remove the racial problems based on skin colour. This would bring in a short-lived era of harmony and peace but fraught with fear, without prosperity, and followed by extensive morbid experiences. Starvation, cancers, cellular abnormalities and sterility would ultimately wipe out the entire population.

But the maximum effect will be reflected in fast depletion of global food supplies, and also on certain aquatic organisms like crabs and shrimp larvae which now live near the limits of their solar UV tolerance. These statements may seem rather blunt, but for understanding the scientific basis of the effects of ozone layer depletion we must first look at the mode of formation, biological action and the most fascinating history of its evolution during the geological times.

Our atmosphere with its abundant oxygen is unique in the solar system, and perhaps in the entire Universe. As we dig deep into the geological history, we find that the present-day ozone layer, situated at about 15 to 20 km from the earth's surface, was formed by a very slow and complex process over 2,500,000,000 years. The story of ozone is indeed a long one and involves geological, hydrological, biological and lithological aspects of the evolution. The formation reaction of ozone can be written as follows:

$$3O_2 \xrightarrow{UV} 2O_3$$

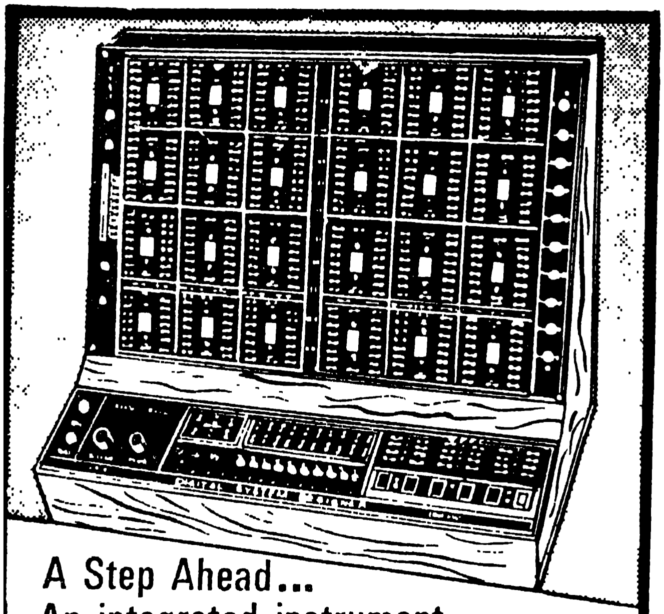
Here UV stands for the ultraviolet light of the sun which consists of a large spectrum of photon energies. The reaction proceeds by the dissociation of oxygen molecules to atoms by the energy of UV photons whose wavelength is less than 242 nanometers (10^{9} metre), followed by the combining of an oxygen atom with an oxygen molecule to form an ozone molecule. The photons of wavelength smaller than 250 nm damage the DNA molecule which is the basis of all forms of life on earth. Since ozone strongly absorbs all UV between wavelengths 200 and 300 nm, the atmospheric ozone layer acts as a protective screen for all life forms on the earth.

In the reaction written above we find that oxygen is necessary for the formation of ozone. When the earth was first formed some 4.5 billion years ago, it had no oxygen in its atmosphere. All the oxygen was bound in the molecules such as water (H_2O), carbon dioxide (CO_2), carbon monoxide (CO), etc. In fact, the atmosphere was highly reducing in nature because of abundance of free hydrogen. This atmosphere was formed by volcanic gases and hot-spring gases. Therefore, the initial step in the evolution of the present day atmosphere must have been the formation of oxygen. However, in view of the interdependence of life and oxygen, we must first look at the story of origin of life.

Fig. 1 Red beds rich in oxidised forms of iron indicate the advent of oxygen in the atmosphere. The earliest continental red beds are less than two billion years old, while those of the Nankoweap formation in the Grand Canyon (above) are about 1.3 billion years old

The abundant sunlight including its UV component must have first started the massive manufacture of the organic molecules in the earth's atmosphere and also probably on its surface. The main constituent elements of these molecules, namely carbon, hydrogen, nitrogen and oxygen, were available in the atmospheric gases of the reducing atmosphere, probably in the form of carbon dioxide, carbon monoxide, methane, ammonia, water and nitrogen. The organic molecules would accumulate in the atmosphere since there were no living beings to consume these. The condensation processes in the atmosphere led to the accumulation of water in the form of ponds on the earth's surface and the organic molecules collected in the ponds. The organic molecules so synthesised included all the major building blocks of the living things of today; amino acids, sugars, formaldehyde and a large variety of simple organic molecules were formed, as proved by the simulated experiments in the laboratory. The organic molecular species in the lower layers of water on earth were protected from the destructive action of the solar UV radiations, thus they could uninterruptedly interact with each other. This led to the evolution of a variety of complex polymers from the simple molecules. A billion years of such interactions would have led some molecular groupings to stabilise. This probably constituted the pre-life. The next stage was the development of procaryotic living cells. Blue-green algae belong to this category. Almost another billion years elapsed before the evolution of eucaryotic life capable of replication by cell division. The unicellular life forms probably sustained themselves without oxygen, by the process of fermentation.

We can now deal with the different stages which led to the evolution of the present-day levels of atmospheric oxygen and ozone. The most primitive mechanism of oxygen production in the atmosphere was the photochemical breaking of water molecules by the solar UV radiations. The equilibrium concentration of oxygen so produced, estimated at 0.001 of the present atmospheric level, was attained very early in the history of the atmosphere. Further increase was initiated by photosynthesis and the blue-green algae are capable of photosynthesising, thus becoming a new source of atmospheric oxygen. These algae must have reached a significant level in the water bodies on the earth about three billion years ago, initiating an exponential increase in the level of oxygen in the atmosphere. This would have led to the second equilibrium level, nearly 2.5 billion years ago, with oxygen content nearly one per cent of the present atmospheric level. By this time biological species, both plants and animals, had evolved into still new forms capable of respiration. At this level the production of oxygen by photosynthesis was balanced by the loss due to respiration. The increasing level



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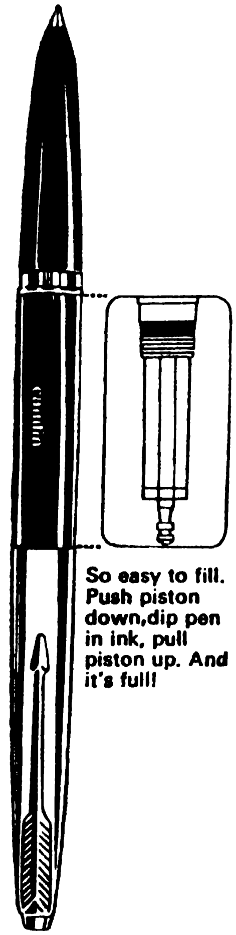

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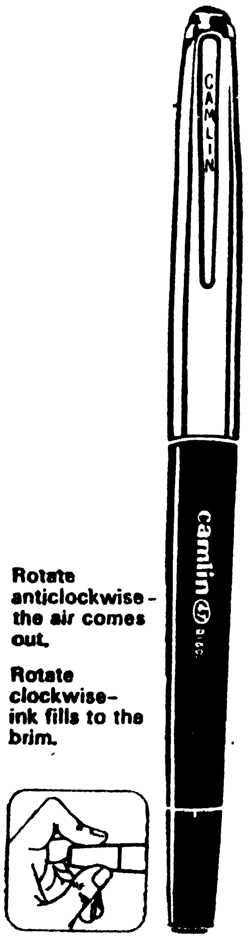
INJECTION PISTON PEN 48



Rotate anticlockwise - the air comes out.

Rotate clockwise- ink fills to the brim.

PISTON FILLING PEN 47

S 793

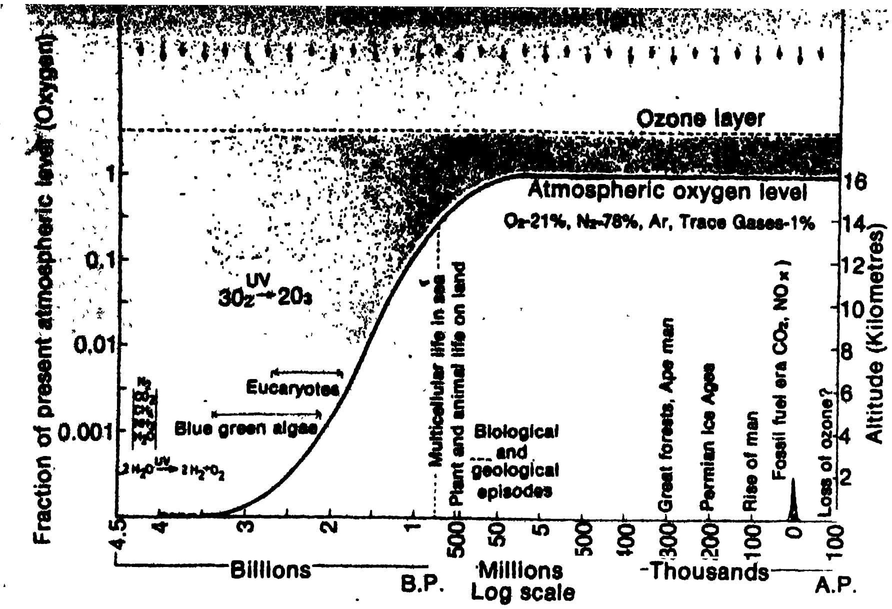


Fig. 2 Evolution of the atmospheric environment and possible impact by man

of oxygen in the atmosphere and the development of an ozone layer considerably reduced the UV component of sunlight reaching the earth. This protective action led to further rapid proliferation of photosynthesising organisms on the earth and rapid increase in the level of oxygen, reaching the present level nearly 0.6 billion years ago.

$$CO_2 + H_2O \xrightarrow{\text{Light}} (CH_2O)_n + O_2\uparrow$$

While oxygen concentration was building up in the atmosphere, ozone was also being formed continuously by solar UV. In the early stages, abundant ozone formation must have taken place at all heights in the atmosphere, even close to the earth's surface. Due to the high oxidation potentials of ozone and atomic oxygen, extensive conversion of ferrous oxide to ferric oxide led to the formation of the so-called red beds, a name given to the geological rock and soil formations consisting of grains coated with red ferric oxide. If the ozone screen is destroyed, UV light reaching the earth's surface would lead to the extensive new formation of red beds as mentioned in the beginning.

The ozone layer must have got separated and elevated to the stratosphere due to a combination of several factors, the most important being the attainment of temperature inversion at some level sufficiently above the ground level, that is, when decrease of temperature with height is reversed. (Normally the upper layers of the atmosphere are cooler than the lower layers.) This inversion took place when sufficient ozone concentration and the reaction heat released by the natural dissociation of ozone caused excessive heating of the higher layers of the atmosphere. The altitude of temperature inversion continued to increase and ultimately stabilised at the present level separating the ozone-heated stratosphere from the troposphere, which is the lowest 10 to 20 km of the atmosphere

How can the ozone screen be destroyed? It can either happen through man's own activities or through a natural catastrophe. Both of these paths of destruction involve certain chemical species which react with ozone rapidly and change it back to oxygen. The most reactive of these species are nitric oxide, hydroxyl radicals, chlorine atoms, and excited atomic and molecular oxygen. Nitric oxide is probably the most important enemy of ozone. High flying aircraft engines, both subsonic and supersonic, discharge effluents which contain nitric oxide in the stratosphere. Extensive use of nitrate fertilisers can lead to large production of nitrous oxide by bacterial action and after reaching the stratosphere, this nitrous oxide can also be converted to nitric oxide. Nuclear and thermonuclear explosions at high altitudes also produce substantial quantities of nitric oxide which can deplete ozone.

Chlorine atoms can be produced in the stratosphere through the UV dissociation of chlorinated hydrocarbons released by man as waste, including leaking refrigerants, aerosol propellants, industrial solvents and future space shuttle releases.

The mechanisms are numerous but we can say that many of the activities of man can lead to a situation bringing about a rapid chain destruction of the ozone layer. The ozone problem differs markedly from other environmental threats, since the ultimate effect is global. A possible natural catastrophic event could be in a very large influx of energetic cosmic rays from a supernova explosion near our solar system (see SCIENCE TODAY, March 1980, p 57). These energetic particles also act through the formation of chemical species, including atomic oxygen, hydroxyl radicals and nitric oxide, that destroy ozone.

It has been predicted that in the absence of regulatory actions world production of chlorofluorocarbons (which are also known as chlorofluoromethanes, including trichlorofluoromethane (CCl_3F) and dichlorodifluoromethane (CCl_2F_2) will grow at an annual rate of seven per cent between 1980 and 2000. The projected depletion of ozone then could become very significant. The very basis of modern civilisation are things which can destroy ozone. However, there is a bit of consolation in the whole episode, though not for us! The ozone screen, once destroyed, would certainly be reformed, repeating the cycle leading to the evolution of plant and animal life once again. The new red beds would tell the story of the folly of *Homo sapiens*, or probably the story of a natural catastrophe. There have been many fascinating cycles and episodes in the geological history of the earth, but this may be a unique one in which human intelligence brings about its own destruction. Should we call it intelligence at all?

K.G. VOHRA

Dr Vohra is Head of the Division of Radiological Protection, BARC, Bombay.

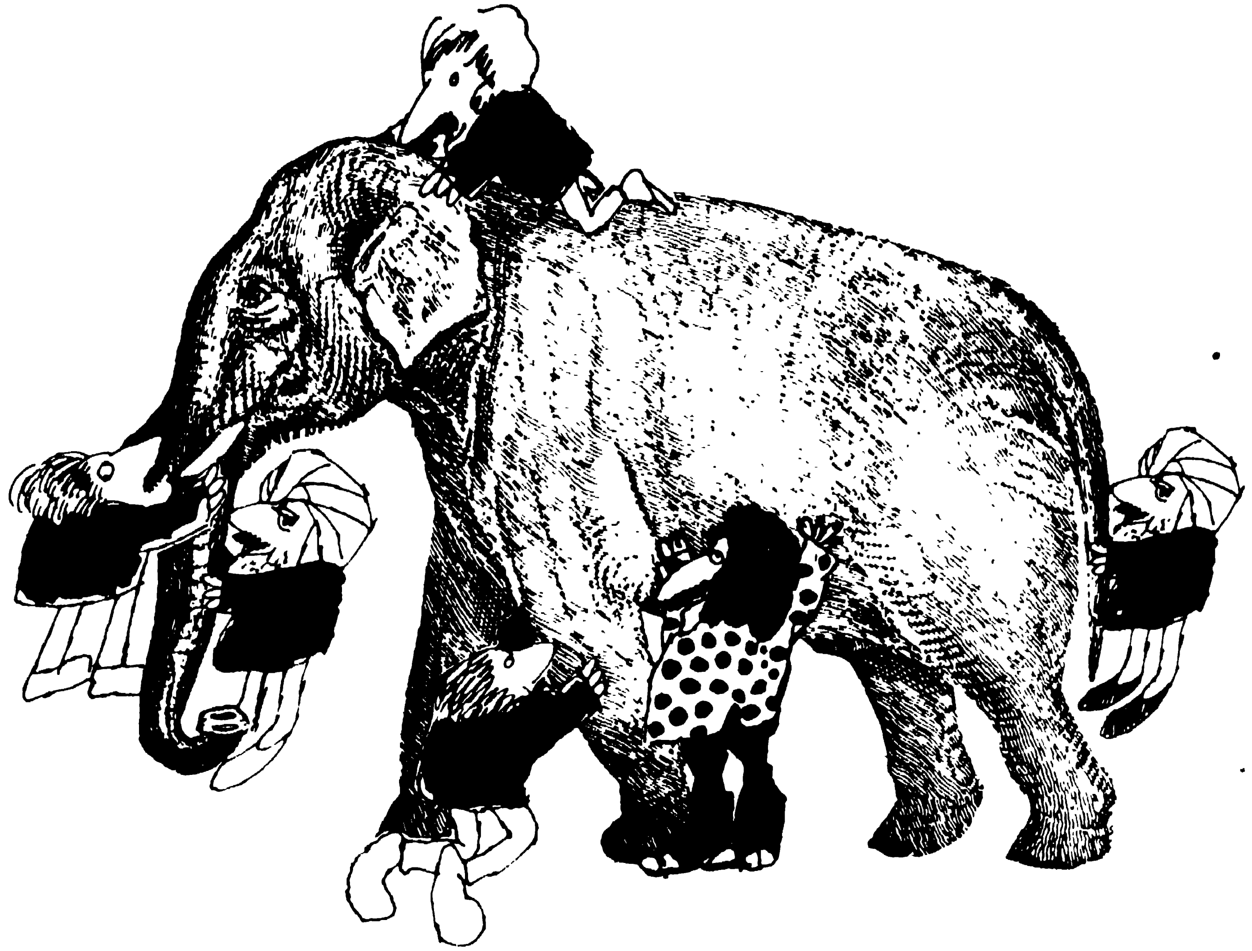
Young Scientists...

(Contd. from p. 55)

proposed. Other groups may take up concrete projects within their institutions. It should be possible to co-ordinate and review the progress of all these projects through a mechanism of communication of young scientists (COYS). How this co-ordination and review are to be done is being worked out through continued interaction with the participants. Scientists who have formed small working groups will prepare an approach paper, including a detailed plan of follow-up action involving individuals or groups at different places, on each of these projects through intense discussions among themselves. These groups will meet regularly and also hold an annual meeting where progress on different projects will be reviewed. The follow-up programme of the symposium will primarily depend on the commitment shown and action initiated by various groups rather than on any centralised mechanism. In this sense, the symposium is only the beginning of a movement which must help young scientists identify their role in society.

The progress of the projects will be constantly reviewed in the *Journal of Young Scientists*. Young scientists and others sharing our interests may join in this stupendous task. It should be possible for them to get involved with these or other projects which they can evolve on their own and co-ordinate with the COYS. Meanwhile, we hope that committed young scientists' effort not only survives but also grows to maturity and delivers the goods.

This report has been written by N. N. Mehrotra, convenor of the symposium, A. K. Singh, chairman, SYS, L. M. Bharadwaj, vice-chairman, SYS, Vijay Kumar, secretary, SYS, and Ramesh Bamezai, convenor of the scientific programme.



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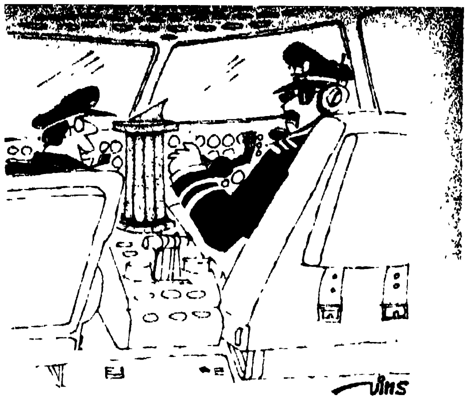
Design of indicators

Krish Pennathur

Whether weight - watching or satellite - launching, what would be the best shape, size, colour or sound of the dials, blinking lights and pointers?



"How do you like the idea of this simplified dial?"

ALL human activity requires monitoring. We use a number of tools and techniques to plan an operation and to forecast its results. But often the end-results do not meet expectations unless the process is watched over and a corrective action taken whenever there is any deviation from the charted path. From weight-watching to satellite-launching, indication of the progress of an activity is a basic requirement if we are to achieve the desired end.

A number of indicators have been devised to help us in this task. For instance, when a doctor has to maintain a four-hourly check on his patient's temperature he uses the thermometer as his indicator. When I host a dinner, I may enclose a guide map to my house along with the invitation. My guests use the guide sketch (the indicator) to find their way. A car driver uses his car lights to indicate his moves to other drivers. The pilot knows how high he is flying from his altimeter. The electricity meter gives an indication to the householder how close he is to the consumption limit imposed by the authorities. The kilometre stones on the road show the traveller how far he has come and how far he is from his destination.

Such indicators or what ergonomists call display systems, are means of providing their users with information they cannot obtain independently. This information is communicated in the form of any one sensory input, usually visual or aural, since the tactile and olfactory displays do not have much practical use.

Requirements of a visual display

The design of a visual display is determined by the type, quantum and accuracy of the information it has to convey. It should be accurate but not supply more information than required by the work system: in a pyrometer reading up to 1,500 degrees Celsius, it is futile to have the gauge marked with graduations of one degree each. More important is the consideration given to the inherent capacity of the human vision to interpret the input. A large and simple display ensures that the message is speedily and correctly read. The response of the instrument to the system's activity should be fast. It should be distinguishable from other displays and adequately illuminated. A built-in warning system to inform the user that the system is not working is essential.

In critical areas it may be necessary to have two or even three sets of signals indicating the same information going off simultaneously to guard against human lapses. The blinking lamp on the dashboard of a car signifies the operation of the trafficator lamps at the car's front and rear ends. Since the lamp may be fused or outside the driver's cone of vision, the visual input is duplicated by a clicking sound which is emitted when the trafficator signals are on.

The principle of management by exception is an intelligent application of ergonomics in display design. When the various functions of a system are operating normally, it is unnecessary to have a battery of instruments all showing the state of normalcy. The non-critical indicator can be eliminated and replaced by warning lamps which light up when a particular sub-system is malfunctioning or when there is a deviation from normalcy. An example of this development is the replacement of the oil pressure gauge in cars by a red lamp which glows when the pressure falls below the minimum acceptable level.

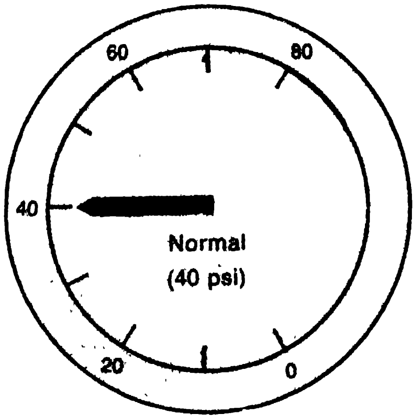


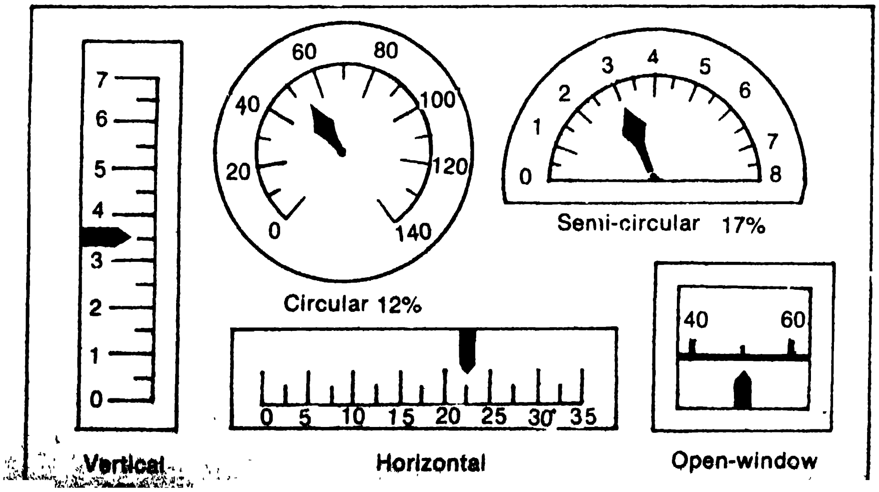
Fig. 1 A typical gauge shows a state of normalcy at the nine o'clock position of the needle. If it is not pointing horizontally to the left, a quick glance will alert the observer that the factor being measured is not under control

Dials

Designed in different shapes and sizes, dials are the most commonly used visual displays. Their design depends on their information content, the viewing distance and the space allotted. Their advantages vary but usually the round dial (see Fig.2) is preferred over the straight-line scale.

Types of dials: A dial could have a fixed scale with a moving pointer or a moving scale with a fixed pointer. In dials where the pointer moves, values can be more easily read off and the deviation along with its directions quickly observed. These are suitable for making adjustments to a required value or for continuous adjustments

Fig. 2 Some dials are more easily and accurately read than others One study investigated these five commonly used types. For an inspection time of 0.12 second the percentage of incorrect readings made with respect to each type is given



Visual displays may indicate information one of the following categories:

Check reading:	System working/not working; on/off
Qualitative:	Condition normal/otherwise and the trend of deviation
Quantitative:	Numerical values; pressure gauges, thermometers; revolution counter
Quantitative-cum-orientation:	Factors of direction, time, space, and magnitude; aircraft instrument panels
Information:	Directional arrows, trafficator indicators; traffic signals, one-way signs; road crossings

during a process. Multi-pointers on the same dial should be avoided since they lead to misinterpretation. Where multi-dimensional information is needed, it is better to have a cluster of single-value dials (one for each purpose).

Dial graduations: The numerical markings on a dial should increase either in the clockwise direction, from left to right, or from bottom to top. The number of divisions between two graduated marks should be kept to the bare minimum (the maximum preferred is nine), since too many divisions slow data interpretation. Numerical progressions in multiples of one, five and 10 are easy to interpret.

Zonal divisions are useful when qualitative readings are to be made. The dial is divided into zones depicting each type of condition (for instance, very low pressure, low pressure, normal pressure, high pressure, very high pressure). These zones can be demarkated by colour as well. Conventionally, green signifies normal and red, near-danger conditions.

Size of letters: Letters and numerals should be chosen in-bold and clear type, ornamental flourishes only confuse interpretation. Some examples of suitable letters and numerals are shown in figures 4a and 4b. Under good conditions of illumination, the height of a letter or numeral should be at least 1/200 of the viewing distance, the width of the character two-thirds of its height, and the thickness one-sixth of the height. Where white figures are displayed against a black background, the line thickness should be reduced to one-seventh or one-eighth of the height, since the white figures against a dark background tend to 'spread out' and appear as a blur. Spacing between characters should be at least one-sixth of the height and between words or a set of numbers not less than two-thirds of the height.

If the dial is fixed with a moving pointer, the figures and letters are placed vertical to the viewer. In a moving dial with a fixed pointer, the characters are written tangentially. The dial should be so oriented that the critical range can be read from left to right or from bottom to top, in order to avoid confusion as to the direction of increase. When two or more scales are located on the same panel, there should be a compatibility of numerical progression and scale organisation between the various scales.

Pointers: Pointers should be simple and functional in design. A pointer is placed close to the dial scale with the values of the graduations marked on the side away from it so that it does not hide the values. Space between the pointer and the dial should be at a minimum to avoid parallax errors in reading. Where accuracy is of great importance, an aid must be provided for perpendicular reading either by positioning a mirror on the face of the dial or by giving a knife-edge to the pointer.

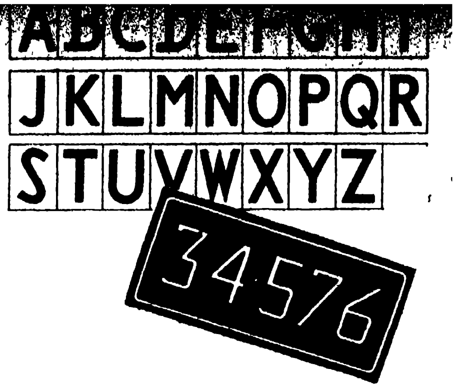


Fig. 4a and 4b Examples of legible lettering (designed by N. H. Mackworth) and numerals (designed by C. Berger)

Table I Classification of pilot errors

Type of errors	Relative Frequency (%)
Misinterpreting multi-revolution instruments	18
Misinterpreting direction of indicator movement	17
Misinterpreting visual and aural signals	14
Errors involving poor legibility	14
Failure to identify a display	13
Using an instrument not pertaining to the function being observed	9
Misinterpreting scale values	6
Errors associated with illusions	5
Omitting the reading of an instrument	4

One approach to the problem of design of visual displays lies in the analysis of errors made by operators in interpreting the information projected by the displays. The table lists the percentage classification of 227 'pilot errors' experience collected by P. M. Fitts and R. F. Jones, two US Army-Airforce psychologists

Directional arrows

The purpose of a directional arrow is to convey to the interested observer the correct direction of movement to be undertaken to arrive at a desired destination. In 1974 I had done a study on the design of these arrows. 117 subjects with normal vision were administered tests for reaction time and interpretation with 81 different types of directional arrows in common use in the city of Bombay. Factors which contributed to longer evaluation time and sometimes misinterpretation, were found to be (a) very narrow head and very long tail of the arrow (b) loops in the tail of the arrow (c) multiple directions (d) preponderance of written message (e) conflict between the 'arrow' and the written direction (f) curved arrows (g) and faded signboards.

Trafficator blinking lights

In a study on the design of trafficator blinking lights in automobiles, carried out by myself in Delhi, some interesting data were revealed. Three aspects deserve mention : the flicker-

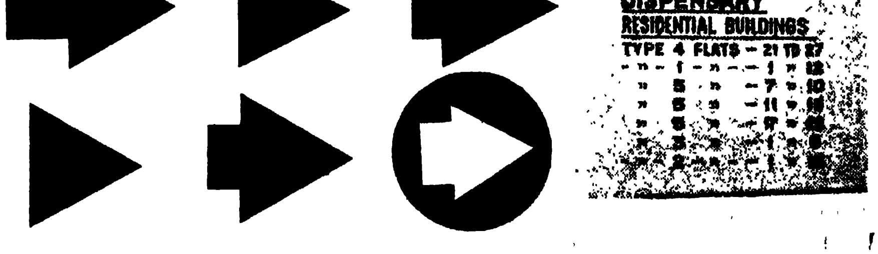


Fig. 3 Various types of direction arrows (above, left) were tested and found suitable by the author. Signboards such as the one at right, confuse the viewer

fusion frequency; the shape of the blinking light; and the colour of the blinking light.

Recognition increased with flicker-fusion frequency. Flicker-fusion frequency can be described, in an over-simplified manner, as the number of times the lamp 'blinks', expressed as cycles per second. One cycle represents the span of time covering the coming on of the light, its going off, till the point of its coming on again. Recognition reached a peak at a flicker-fusion frequency of 2.5 cycles per second after which it started dropping. Considering the fact that higher frequencies induce greater irritation and eye fatigue, it was concluded that the optimum flicker-fusion frequency for maximum recognition was around 1.5 cycles per second (cps).

The advantages of yellow, amber and red as colours of warning have been reinforced by custom and usage. Since brake lights are traditionally red, an amber colour for trafficator blinking lights appeared to be the most suitable.

Among the various shapes of the blinking lights experimented with, highest recognition and correct interpretation (99 per cent) was found when the shape of the light was triangular, with the base of the gle 1.33 times the length of the other two equal sides and with the apex pointing towards the direction of the intended turn.

Some other observations made in the study were:

the wattage of the blinking light bulb could be around 25 watts;
when the trafficator is on, the aural signal for Indian conditions should be between 8,000 and 10,000 cps in frequency and about 50 decibels in volume;
the visual indicator on the dashboard should be located between 17 and 22 degrees of the driver's cone of vision;
the positioning of the blinking lights could be:
— 75 to 90 cm from the road surface
— 80 to 105 cm on either side of the longitudinal axis of the car
— above the brake light.

Aural displays

At present we find visual displays predominating, perhaps because human beings depend more on their eyes than on any one of their other sensory organs. Also, designers have traditionally not developed upon the potential of aural displays. Apart from call-bells, telephone rings, sirens and buzzers, aural inputs are not much to be heard about the environment.

In fact, the human auditory system is extremely versatile. While visual signals can be perceived only when the signal is within the zone of vision, auditory signals allow much greater flexibility. In addition to localising the source of the signal, the human ear can analyse it and screen the signal from the background noise. Auditory signals are potentially superior to visual signals in situations where (a) a message is simple, short and requires immediate action (b) the operator has to be on the move (c) poor illumination or physical restrictions interfere with reception of visual signals (d) there are too many simultaneous visual displays and (e) at high altitudes and under gravitational pressure. In the current industrial environment, there is an overload on visual inputs, and as such considerable research effort is definitely indicated in this area.

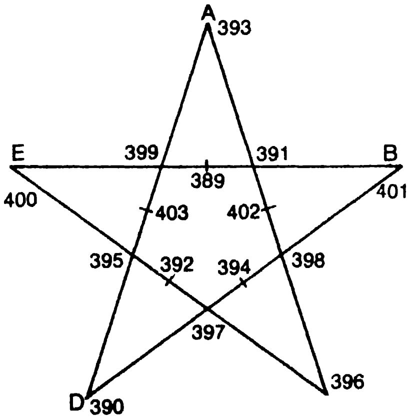
Brigadier Pennathur got his Ph D in Industrial Management from Delhi University. He was the founder-director of the Defence Institute of Work Study. He is currently co-ordinating the Commonwealth Research Programme on Standard Rate of Performance of Workers and is also conducting ergonomic research on the Indian aocio-industrial environment.

Fun with Mathematics

Magic star for 1980

It is possible that 1980 may well be remembered as the year of the total solar eclipse in India. At many places two planets (Mercury and Venus) were also seen during the over two minutes of totality. I now present a magic pentagonal star for 1980 to celebrate this important event.

All the numbers 389 to 403 are taken only once in preparing this magic star and we get the sum 1980 by adding five numbers in eight different ways: the five corners of the star ABCDE add up to 1980 as do the corners of the inscribed pentagon and the midpoints of the pentagon. Also, the five numbers along each of the five lines, AD, AC, BE, BD and CE all add up to 1980.



D.R. KAPREKAR

Prime numbers

One very interesting and intriguing property of prime numbers is that they make perfect divisors of numbers formed by writing 1 1 1 1 .... 1, as many times as the number, less one. For example, 59 will perfectly divide the number 1 written 58 times. The relationship does not hold good for the first three prime numbers 2, 3 and 5, which are more or less notional prime numbers. In some [illegible] the prime numbers divide perfectly a part of the said number, but the part should be a divisor of the whole number. For example, 41 divides 1 1 1 1 1, one written five times, which is only 1/8th of 40. However, the proposition, which is applicable to all prime numbers, is as stated above. I have verified this up to prime number 103 manually and invite mathematicians and wizards of numbers to verify and confirm the proposition, may be with the help of computers.

H. D. GUPTA

Products of squares

In the world of numbers, there are quite a few numbers which can be expressed as the sum of two squares. For example, $5 = 2^2 + 1^2$; $10 = 3^2 + 1^2$; $13 = 3^2 + 2^2$; $17 = 4^2 + 1^2$; $20 = 4^2 + 2^2$ and so on. These numbers give some interesting results. For instance, the product of two such numbers which do not have a common factor can be expressed as the sum of two squares in two different ways. To illustrate: $5 \times 13 = 65 = 8^2 + 1^2$ or $7^2 + 4^2$; $10 \times 13 = 130 = 11^2 + 3^2$ or $9^2 + 7^2$; $5 \times 17 = 85 = 9^2 + 2^2$ or $7^2 + 6^2$; $13 \times 17 = 221 = 14^2 + 5^2$ or $11^2 + 10^2$ and so on.

The product of three such numbers without a common factor can be expressed as the sum of two squares in four different ways. Therefore we have,

$5 \times 13 \times 17 = 1105 = 33^2 + 4^2$ or $32^2 + 9^2$ or $31^2 + 12^2$ or $24^2 + 23^2$;
$10 \times 13 \times 17 = 2210 = 47^2 + 1^2$ or $43^2 + 19^2$ or $41^2 + 23^2$ or $37^2 + 29^2$

Can we extend these results to conclude that the product of n such numbers can be expressed as the sum of two squares in 2^{n-1} ways?

JAYASHREE S.

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2 Science Today, April 1980

How much do you know about TOBACCO SMOKING?

"Smoking or Health: the Choice is Yours" is the theme adopted for this year's World Health Day, 7 April. Here are 20 questions on smoking. Answers overleaf.

1. Of cigars, *bidis* and cigarettes, the ones most frequently smoked in India are A cigars. B. *bidis.* C. cigarettes.

2. Besides lung cancer, tobacco smoking can A. cause problems for the heart and stomach B. cause no problems for the heart and stomach. C. cause problems for the heart only.

3. If a pregnant woman smokes heavily she is likely to have A an overweight baby. B. an underweight baby. C. a caesarean delivery.

4. With smoking the pulse rate and blood pressure A. increase. B. decrease C remain the same.

5. White-collar workers generally smoke A. more than blue-collar workers B less than blue-collar workers. C. just as much as blue-collar workers

6. Studies have shown that the health of non-smokers who stay in the company of smokers A. can improve. B. is unaffected. C. can be adversely affected.

7. The country that produces the most tobacco is A. the USA B. China. C. Turkey.

8. Cigarette smoking can be most responsible for A. lung cancer B lung tuberculosis. C. lung abcess.

9. Of the drugs used to cure the smoking habit, the most effective are A placebos. B nicotine chewing gum. C. tranquillisers.

10. Studies have shown that A. it is all right for women who smoke to take contraceptive pills. B. it is risky for women who smoke to take contraceptive pills. C. women who smoke can often get pregnant in spite of contraceptive pills.

11. The most effective way to cure the smoking habit is by A group therapy. B. drugs. C hypnosis

12. Cigarette addicts who cannot stop smoking should use A cough syrups. B. imported brands. C brands with reduced tar and nicotine.

13. Health hazards associated with cigarette smoking can be reduced by lowering the levels of A. tar B nicotine. C. carbon monoxide.

14. In which of the following (identify one or more) industries is the occupational risk of lung cancer for smokers higher than normal? A. Nickel. B. Asbestos. C. Construction. D. Uranium mining.

15. In India *bidi* smoking as well as *pan* chewing are known to be related to mouth cancer (see SCIENCE TODAY, August 1978). The risk of mouth cancer from *pan* chewing as compared to *bidi* smoking is A. lower. B. equal. C. significantly higher.

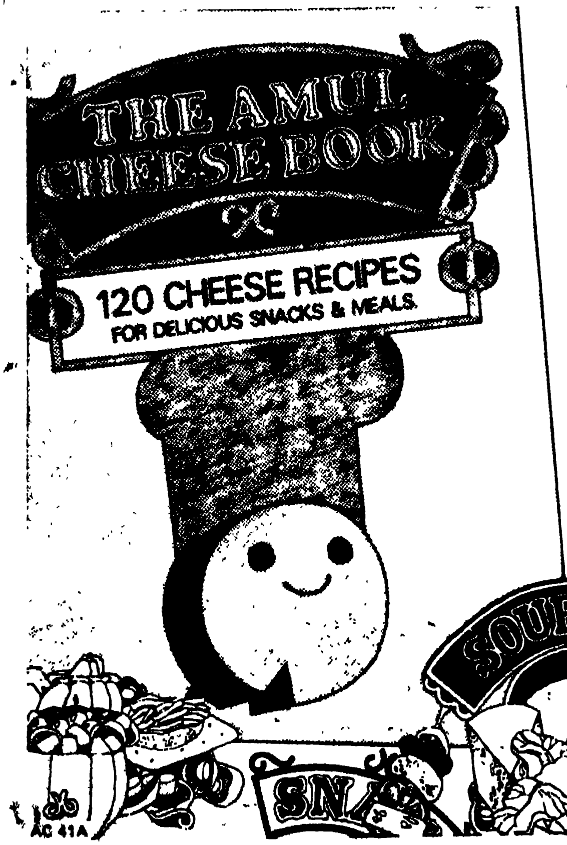
16. Of the three, cigars, pipes and cigarettes, the most harmful to health are A. cigars. B. pipes. C. cigarettes.

17. The abbreviation 'NSM' stands for A. new smoking material. B. non-smoking measures. C never smoke menthols.

18. The per capita consumption of cigarettes in the developed countries is A. more than that in the developing countries. B. less than that of the developing countries C as much as that of the developing countries.

19. Taxation arising from the tobacco industry A. certainly helps a nation's economy. B need not necessarily help a nation's economy. C. can adversely affect a nation's economy.

20. Legislation on tobacco in some industrialised countries has caused them A. to sell tobacco with high nicotine and tar content to developing countries. B. to look for substitute crops. C to destroy large bulks of tobacco.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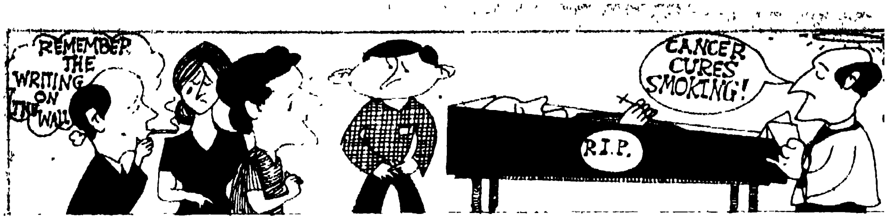
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The Answers

1.—B: *Bidis* are the most smoked of the three in India, especially in the rural areas. The nicotine content of *bidis* is, depending on its size, two to three times that in cigarettes, and *bidis* pose a greater risk of lung cancer according to a study by the Cancer Research Institute, Bombay. Home-made cigars, called *chuttas* are commonly smoked in coastal Andhra Pradesh.

Quantity of tobacco and size of leaf used for a single bidi

2.—A: Tobacco smoking can lead to both fatal and non-fatal heart attacks. It can also cause hyperacidity of the stomach. Smokers face double the risk of gastro-duodenal ulcer as compared to non-smokers. So is the case with bladder cancer, according to a New York study. It has also been found that young people who suffer from ischemic disease of the legs, where the blood circulation gets blocked, are invariably smokers. Apart from these, smoking can also lead to a number of other diseases like chronic bronchitis and emphysema (loss of elasticity in the lungs).

In many countries, the average age at which people start smoking is 10. The habit is usually carried on even in old age

3.—B: Babies of mothers who smoke tend to be around 200 gm underweight and more susceptible to disease. The exact reason for this is still not sufficiently known. It may be the direct toxic influence of nicotine, carbon monoxide or any other constituent of tobacco smoke. Or it may be the result of an impaired blood circulation to the placenta, which provides nutrition to the fetus. Release of oxytocin (a hormone) and disturbance of vitamin B-12 and vitamin C metabolism are other theories propounded. In any case, says a publication of the World Health Organisation (WHO), "Maternal smoking retards fetal growth and increases the risk of death immediately after delivery. Risk of perinatal death increases by nearly one-third in mothers who smoke regularly after the fourth month of pregnancy."

"Is it fair to force your baby to smoke cigarettes?" was the slogan below this poster published by the UK Health Education Council

4.—A: Nicotine stimulates the entire sympathetic nervous system and it has been reported that smoking increases the pulse rate by 20 beats per minute. This may last 10 to 20 min after a person stops smoking. In at least 8 out of 10 persons, the increase in blood pressure will persist for any length of time from 10 min to an hour after smoking a single cigarette.

5.—B: It is known that the higher the occupational status and the more educated an individual is, the lower is the prevalence of smoking and the quantity of tobacco otherwise consumed. It is also seen that individuals in the lowest occupational levels tend to start smoking earlier and in greater numbers than those in higher levels. However, there seems to be no direct relation between IQ scores and smoking.

6.—C: Non-smokers exposed to tobacco smoke can find it irritating. Ill-ventilated space with tobacco smoke can create harmful concentrations, especially of carbon monoxide. This may impair certain psychomotor performances like car-driving. The smoke can irritate the eyes and throat and precipitate an asthmatic attack in particularly susceptible persons. "Cigarette smoke contains over 1,000 substances; and some, such as tar, carbon monoxide and nicotine, are found in higher concentrations in the side stream smoke (given off between puffs) than in the main stream," says an editorial in the *British Medical Journal*. Again, an American study has shown that the concentration of nitrosamines — potent carcinogens in some animals, although not yet linked to human cancer — is 50 times greater in the side stream smoke than in the main stream. This is why an increasing number of airlines today have special non-smoking sections, since otherwise non-smokers would also be "passive" or "involuntary" smokers.

Norwegian cartoons spell out the problem

7.—B: China produces over 1 million tonnes of tobacco annually followed by the USA with 960,000 tonnes. India comes next with 380,000 tonnes. The USSR produces 318,000 tonnes and Turkey 300,000 tonnes. Many other European, Asian and African countries are also important producers.

8.—A: The risk of developing lung cancer is clearly related to the number of cigarettes smoked, the age of onset of smoking and the manner of smoking that decides the exposure of the lungs to the constituents of tobacco smoke, like the frequency of puffing, the retention of the cigarette in the mouth between puffs and the degree of inhalation.

9.—B: Nicotine chewing gum is perhaps the best drug therapy. In one study it achieved 70 per cent abstinence during treatment, which fell to 23 per cent a year later, says a WHO report which also mentions that "placebos which give an abstinence rate of 25 per cent with virtually no relapse up to a one-year follow-up, were consistently more effective than tranquillisers".

10.—B: Studies have revealed that a combination of cigarette smoking and contraceptive pill use can lead to serious heart attacks and circulatory disorders in women. Hence it is better for women who smoke to adopt other methods of contraception.

11.—A, B, and C: All these have their place in treatment, their effectiveness depending on the individual concerned. Sometimes, when combined, they produce better results. In any case, treated subjects, whatever be the method, are able to reduce or totally abstain from smoking much more than untreated subjects who wish to give up the habit.

12.—C: It is possible to reduce the tar and nicotine content of cigarette smoke by the use of filter tips, by manufacturing cigarettes from only certain parts or varieties of the tobacco plant, by addition of various chemicals, or by increasing the porosity of the paper used so that combustion is more complete.

Another technique is to replace tobacco in a cigarettes by a cellulose-like material which when burnt produces a nicotine-free smoke having a relatively low tar content and, in addition, possessing low carcinogenity.

The "whisky pipe" was one gimmick that didn't click. Here the smoke is filtered through a mixture of whisky and water, thereby reducing the nicotine and tar inhaled, while also flavouring the smoke with whisky

13.—A, B, and C: All these components are potentially harmful, be they in particulate or in gaseous forms. Lowering the levels of all or any of them is good for the health of the smoker.

A huge cigarette advertisement in London dwarfs the comparatively tiny anti-smoking poster near it

14.—A,B, and D: There is statistical evidence of an interaction effect. A significantly higher percentage of smokers in these industries die of cancer than smokers elsewhere. Also, a recent study indicates that asbestos fibres concentrate carcinogens, possibly playing a catalytic role in causing the disease.

15.—C: Smoking affects the lungs and the heart more, while *pan* chewing affects the mouth more. It is, however, seen that if a *pan* chewer also smokes *bidis*, the risk of mouth cancer becomes significantly higher.

16.—C: Of the three, cigarettes can cause the greatest harm since most pipe and cigar smokers do not smoke as much. Nor do they generally inhale as much smoke as cigarette smokers. Even though cigars and pipes are less dangerous than cigarettes as far as lung cancer is concerned, they can cause cancers of the larynx and esophagus. Pipe smoking, in particular, has been clearly linked with cancer of the lips.

Factory hands sort cigars according to their thickness by passing them through a guage

17.—A: "New smoking material" is the cellulose-like material referred to in 12 above. NSM is made of wood pulp and consists almost entirely of cellulose, and except by its colour, it is indistinguishable from tobacco (see SCIENCE TODAY, July 1973 p.9).

18.—A: The developed countries consume far more cigarettes per head than the developing countries. The USA leads with over 2,700 cigarettes per person per year. For Western Europe the figure is between 1,000 and 2,000. However, the trend is changing. Developing countries are rapidly consuming more cigarettes, and, with scanty resources at hand, it looks like many third world countries may soon find it difficult to keep on meeting the increasing cost of treating affected persons.

19.—B: The report of a WHO expert committee on smoking published last year says: "There is a common misconception that tobacco taxes are in the public interest since they generate revenue for the government. It should be kept in mind, however, that taxation does not recreate the gross national product lost nor the work days lost as a result of smoking related diseases. Some amount of revenue could just as well be raised in other ways. The only advantage of tobacco taxes is that they are politically comfortable for governments as they are easy to administer and generally acceptable to smokers."

20.—A: Certain qualities of tobacco, the use of which is banned in industrialised countries on account of its high tar/nicotine content is often sold to third world countries where no such legislations exist. In addition, says the WHO *Chronicle*, enterpreneurs from industrial countries, with their markets saturated or discouraged at home are moving to untapped markets in the third world, where, often, health education campaigns and control activities do not exist.

"Buy our cigarettes now, get sick, then come back and buy our drugs!"

This quiz was prepared by SCIENCE TODAY in consultation with SAROJ S. JHA, Professor and Head, Dept of Preventive and Social Medicine at the T.N. Medical College and B.Y.L. Nair Hospital, Bombay, and P.C. GUPTA who is with the Oral Cancer Research Group at the Tata Institute of Fundamental Research, Bombay.

The Doctor as Detective

The question of motive

Pritam P. Phatnani

Establishing the motive for a crime, in the absence of other clues, can often help in hooking the criminal. The fourth 'W' —the 'Why'—in the series

WINE, women, and wealth are said to be the common causes for murder. I will add a couple more, namely vengeance, specially political, and blackmail. At times, however, there is no particular motive for murder: the killing is spontaneous and takes place in the heat of an argument on the spur of a moment. In fact, very few of the murders that take place in our country are cold-blooded and calculated.

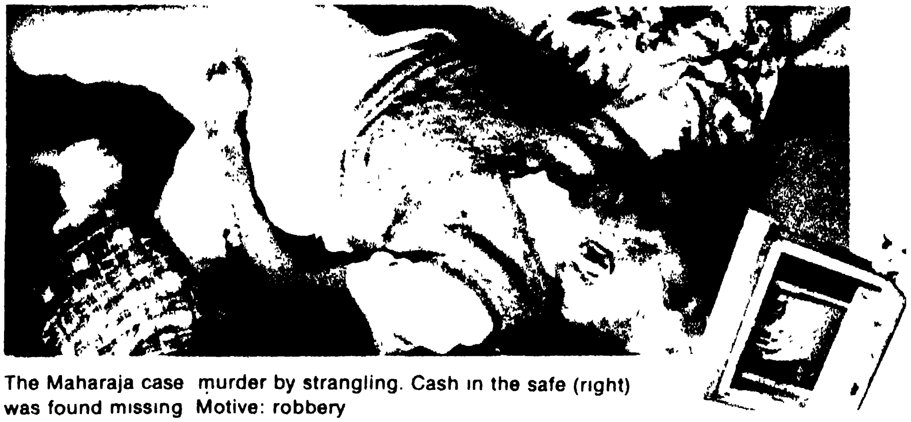
Let us now examine these motives individually. Murder for gain, specially by way of thefts and robberies, occurs when the victim resists the robber or struggles with a robber armed with a knife or a gun. Disputes over land and property often lead to murders. In such cases the burden of investigation is chiefly on the police and a lot depends on the co-operation of the witnesses to the crime or those who have been robbed themselves.

The thrill of the detection, calling for all the skills of the investigating officer, comes when there is a cold-blooded, calculated murder for gain. Two such cases were dealt with by the author, one of which was a case of double murder.

A general sales manager of a well known paint company and his wife were found murdered in the bedroom of their posh flat with multiple stab wounds. Their nephew who used to stay with them was found tied with ropes in the drawing room. In another room, almirahs containing valuables were ransacked and jewellery, cash and clothing, etc worth about Rs. 50,000 were found missing.

On interrogation, the nephew's story was that after midnight when he answered a knock at the door, four strangers forced themselves in and at knife point tied him up and robbed the place. His uncle and aunt were murdered when they were awakened by the noise and attempted to resist the robbers. But there was one slip in his story, which proved fatal to him. Postmortem examination of the victims revealed that they had died before midnight.

Further investigations revealed that, in fact, it was the nephew who had planned the murder. The couple was childless and they had adopted their nephew, educated him and given him a sales job in the same company. This young man instead of being grateful, had designs on their property and hired four people to murder his uncle and aunt, promising the assassins Rs. 1,00,000 for doing the job.



The Maharaja case murder by strangling. Cash in the safe (right) was found missing Motive: robbery

The Maharajah of Vijayanagar was strangled to death in the sixth floor room of his apartment by the watchman he had signed on 15 days earlier. The Maharajah, who was suffering from hemiplegia was killed in the night by the assailants, who took away Rs. 15,000 from a safe, but did not touch the ammunition.

Women are frequent victims of murderers. Where rape is combined with murder, as is often the case, a doctor's role becomes more important. One of the most sensational cases of this kind was what came to be known as "The Colaba Call girl case".

A Yugoslav national brought a call girl to his sixth floor apartment in Colaba at about 6 pm for the Yugoslav national day celebration party. They had dinner together and went to bed. At about 1.30 am the watchman of the building heard a woman's scream and the sound of an object falling. On investigation he discovered the call girl lying dead in the compound of an adjacent building. She was naked from the waist up and her frock was half torn. The brassiere was missing. A team of investigators including forensic pathologists rushed to the spot.

On detailed examination of the spot they discovered the woman's under-clothing lying scattered at various places around the body and dangling from a pine tree beside the building. A bath towel and a bedsheet were also lying some distance from the scene.

What could be the motive for this killing? After the girl's body was identified and her profession known, sexual involvement was taken for granted. She did not have anything valuable on her person and hence robbery could apparently be ruled out as a motive for the killing.

Motivation and the media

MANY people are concerned with the amount of violence and crime that children see on TV and have wondered whether this might motivate them to commit crime. It is true that the more hours a child spends watching violence on TV, the more likely he is to express aggression in personality tests designed to measure hostile feelings. But we don't know whether the many fights he sees on TV have made him more aggressive or whether he is already aggressive and finds in watching TV an outlet for [illegible] ssion. It is true there are a number [illegible] ll-documented cases where young [illegible] quents have committed a crime [illegible] they have seen performed on the TV or motive screen. For instance, the [illegible] Fs bank robbery in Bombay was

Careful examination of the body revealed a shiny streak of dried seminal fluid at the back of her right thigh moving in a pattern which is possible to make only during the foreplay. This streak stopped short of the anal orifice on the buttock. Obviously there had been an attempt at unnatural sexual intercourse, which the woman must have resisted, leading to her being pushed out of the window in the ensuing struggle.

This conclusion was supported by a survey of the man's room in the building which showed all the signs of a struggle having taken place, like disturbed articles, broken curtain rings, etc. Physical examination of the suspect also showed marks of injuries on his chest, obviously caused by the nails of the woman.

No age is safe from sexual assault. A five year old child can be raped and murdered, as happened behind Babulnath temple near Chowpatty, (Bombay). A middle-aged housewife staying in a posh locality of south Bombay was done to death in a similar manner.

The "eternal triangle" is a frequent cause of murder. The famous Ahuja murder case of Bombay and Mrs. Jain murder case in Delhi are among the well known cases involving the love element.

Occasionally, jealousy can turn women to murder. Dr. Gautam of Lucknow died at the hands of his lover Shamin Rehmani. In the Hirabai Gorak Prasad affair of Chandni Chowk, Delhi, Hirabai killed three young girls with arsenic. Sarju Prasad, a 65-year old landlord of Rewa, Madhya Pradesh, was poisoned by his pretty 25-year-old wife, because of psychological maladjustment between the couple due to the disparity in ages. Where there is a paramour, and either the husband or wife is killed, the motive is very often sexual jealousy.

Another type of murder which is generally associated with women is 'infanticide', where the mother kills her child either due to the psychological strain of pregnancy and child-birth or because the baby is illegitimate. Statistics show that 15 per cent of murders are committed by women and almost half their victims are their own offspring. Often baby girls have been murdered because the mother wanted a boy and not a girl. At times the babies are killed because the mother is financially unable to bring up the child.

Children are murdered by men, too. There was a case in which the husband suspected the fidelity of his wife and claimed that children born to her were sired by the neighbour; he killed two of his children.

A man from Surat killed his three step-brothers and sister aged 2 and 5 years because of property rights.

Often children are killed for ransom, for example, the famous 'Bunty' case which took place in Kalyan, Bombay. Children are also murdered ritualistically by men who claim supernatural powers or wish to acquire them. A tantric sadhu (who later died in police custody) in Bangalore and his disciples were arrested for cutting the necks of children to obtain blood for tantric rites. In the Manwat (Maharashtra) case, children were sacrificed to enable barren women to conceive.

Drunken quarrels, political vengeance, sudden quarrels and street fights are almost exclusively the privilege of men. The majority of murders take place in the heat of the moment. Gang warfare amongst members of the underworld occasionally creates headlines in the newspapers. Petty quarrels during gambling, too, often result in murder. These cases occur mostly in lower socio-economic strata of the society.

Politically motivated murder is an international phenomenon taking place from time immemorial. It calls for all the skill of the investigators.

The forensic pathologist can aid the investigating officer in establishing the motive for the crime by making a detailed examination of the scene of crime. There is a search of the place for any letters like suicide notes specially in cases where there is a pact amongst lovers or there is a murder of one partner followed by the suicide of another. The psychology of the crime becomes an important factor to determine.

'Colaba call girl' lying semi-nude on a heap of stones after she was thrown out of the window of the apartment house

Where there are lust murders, there is careful examination of the body of the victim for any evidence of sexual assault, of her private parts and collection of even trace material for laboratory investigations, examination of the surroundings for evidence of struggle, and that of the clothing for any foreign material or blood and seminal stains, etc. Has the victim during her struggle left marks on any part of assailant's body or clutched at his clothing and thus retained shreds of it? And, of course, the nature of injuries also indicate the intent of the assailant. The recent case of the Chopra children in Delhi involving the notorious Billa and Ranga is only too fresh in public memory.

inspired by the movie *Highway 201* and the youth who broke into the National Museum, New Delhi, admitted that he got the idea from *How to Steal a Million*.

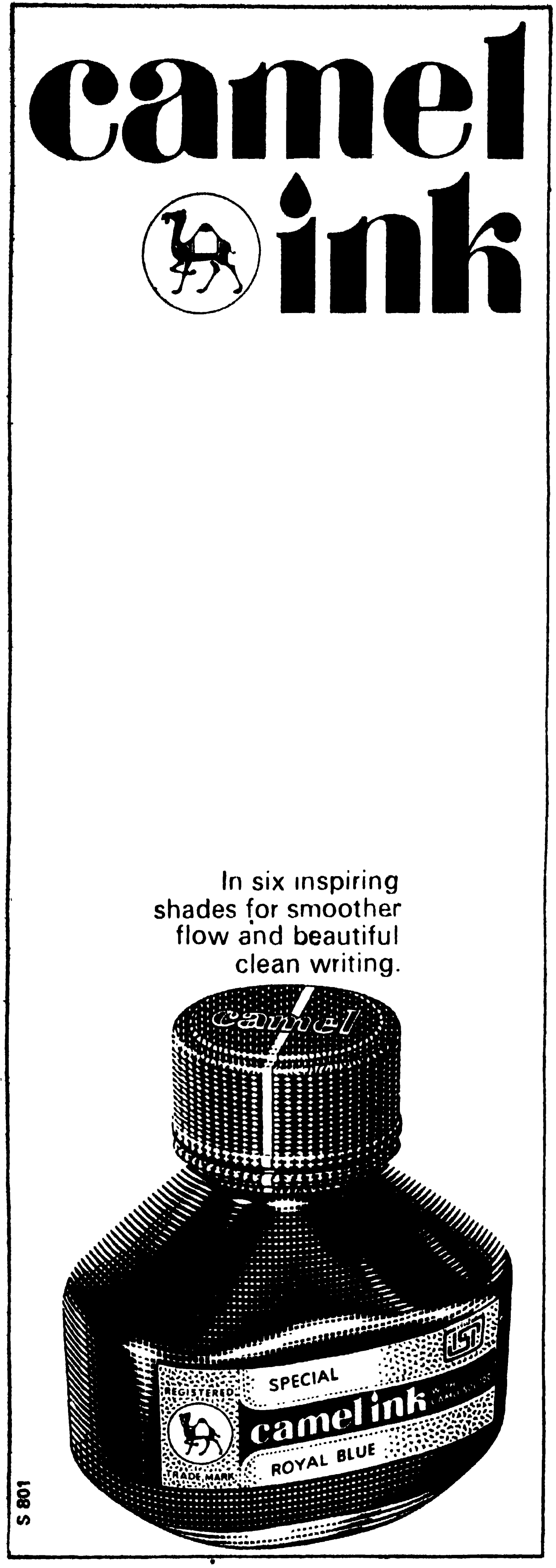
But the large majority of children who see the same crimes on the screen as the delinquents do not go out and imitate them. And we can always discover factors in the background of a young criminal that predisposed him to commit the crime.

Whether or not a child imitates what he has seen will depend on many other things too. It would depend on whether the behaviour he sees is consistent with the moral standards of behaviour he has been taught. Where children have already acquired knowledge or values on a subject, TV seems to have little effect. In a certain sense, the influence of TV is unique on each child. A US Senate Subcommittee in 1955, after investigating the relationship between juvenile delinquency and crime reported *inter alia*: 1) Scenes of violence and crime may teach techniques of crime to children; 2) Acts of crime and violence may provide both suggestions and a kind of support for the hostile child, leading him to imitate these acts in expression of his own aggression.

Stanford University Institute for Mass Communication Research conducted a survey on the influence of TV on 6000 children, 2000 parents and 300 teachers and found that though there was some influence on the young minds it was not serious enough to lead them to deliquency. However, if they had delinquent tendencies already, TV only served to trigger them off.

P.P.

Dr. Phatnani heads the medical education division of a well-known pharmaceuticals firm and is guest lecturer in Forensic Medicine at the Seth G. S. Medical College, Bombay.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...why are some people obese?

"MORE MONEY is spent on worthless cures for obesity than is spent on all of medical research", says a book *Recent Advances in Obesity Research* published in 1977. That sums up the concern for obesity, a problem that not only affects a person's good looks but is said to result also in a host of cardiovascular problems, diabetes, gall-bladder disease, endometrial carcinoma, many psychological disorders and a shortened lifespan, to name but a few.

'Obesity' describes an excessive accumulation of body fat which usually results from the intake of more calories than the body can utilise. The excess calories are then stored as fat or adipose tissue. In general, the term 'obese' applies to persons who are 20 per cent or more overweight. The problems of obesity arise mainly due to the greater work-load on the heart, since every additional kilogram of fat is said to add three kilometres of blood vessels!

Storing fat is the body's means of building up its energy reserves. The number of fat cells (adipocytes) present in an individual at birth is genetically determined, and a new crop of cells may be added in early childhood. The general belief that a fat child will grow up into a fat adult has some truth, for, an overfed child invariably has the tendency to gain more fat cells. The percentage of fat cells in women is more (18 to 24 per cent) than in men (12 to 18 per cent).

Fat people often eat too much, making them more fat. The problem stems often from a damaged control system for food intake. The hypothalamus in the brain controls the feelings of hunger and satiety. Sometimes the centre that produces satiety may be destroyed, thus causing an unending desire for food. Psychological factors, habit and social customs are the predominant causes of hypothalamus maladjustment.

A bad eating pattern can lead to obesity. An individual's food habits take shape in childhood with a variety of factors like family influence, religion and custom playing a role. The obese not only eat too much, but they also tend to eat too much food of the wrong kind—starchy, sweet and oily—that only helps add to their reserves of fat.

When many fat people claim to eat no more than their thin friends do, they do not account for the things they eat between their regular meals. Often, the activities that obese individuals consciously or unconsciously associate with food can become signals for eating—it's no wonder why people munch without end while watching television or a cricket match or while travelling by train. Stress and insulin response may also stimulate an obese person to eat more.

The body requires a certain amount of energy for the smooth functioning of its metabolic and physical activities. When a person takes in more calories than his body needs, the excess is converted into fat. The important point is that even a small caloric excess when continued for a long period can eventually result in pronounced obesity. Individual caloric requirements vary enormously, and it is possible that a person of low metabolic rate, small stature and sedentary habits has an excess of calories in spite of a very moderate food intake. Thus, the quantity an adult should eat must depend on his occupation and physical activities. In the early years and during adolescence, an individual's food requirement is high. Also, a pregnant or nursing woman needs more food than normal. However, if she does not revert to her normal diet afterwards—and this does happen often—obesity results. Obesity in old age has been attributed to the decline in muscle cells and the body's metabolic rate in addition to the reduced physical activity.

Lack of physical activity is a major cause of obesity. Recent studies have revealed a startling physiological relationship, that a low level of physical activity itself may lead to increased eating. Indeed, in this respect, present-day living in the developed countries is congenial to obesity. Mechanisation has reduced hard physical labour in industry, farming and the home. The automobile and modern communication methods have also contributed to the decrease in calorie expenditure.

Though this is relatively rare, hormonal malfunction can also lead to obesity. For instance, an excess secretion of adrenocorticotropic hormone (ACTH) can result in a complex of symptoms including facial and truncal obesity, often termed medically as Cushing's syndrome. A deficiency in pituitary growth hormone can result in a relative increase of fat. So can thyroid deficiency.

Obese persons are often found to have elevated plasma insulin levels, as large fat cells are refractory to the action of insulin. Besides, the increase in the production of cortisol, a hormone that acts mainly in carbohydrate metabolism, by the adrenal cortex encourages fat formation. Recently, it has also been understood that sex steroids used in many oral contraceptives often play a role on the sites of fat accumulation.

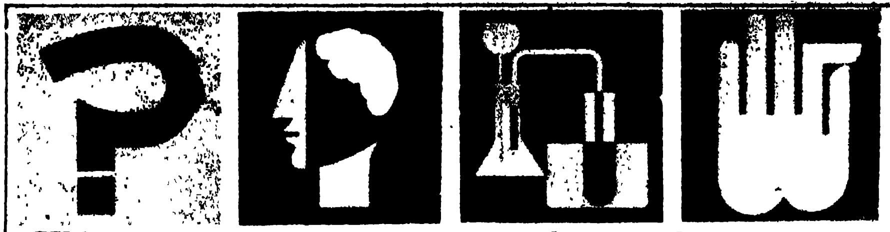
It may come as a surprise to some that most cases of familial obesity are the result of environment and habit rather than genetic or hormonal. So caution right from childhood, which should include proper physical and dietary training, can help prevent obesity. And as for reversing the state of adult obesity, a permanent lifelong change in food habits and behaviour could be the only solution. "A hypocaloric high-protein diet in addition to a couple of hours of brisk walking can work wonders", says a specialist who runs an obesity clinic.

S. SITARAMAN

Dr. (Mrs.) Sitaraman has worked on adrenal hormones.

MEN				WOMEN			
	Weight in kg				Weight in kg		
Height, cms	Age			Height, cms	Age		
	20	35	50		20	35	50
148	42.7	47.6	50.9	148	38.6	44.0	47.1
153	45.4	50.4	53.5	150	40.3	44.8	47.7
158	48.6	53.5	56.3	153	41.9	46.6	49.5
163	51.1	56.3	59.4	155	42.8	47.7	50.1
168	54.0	60.1	63.7	158	44.9	49.5	52.1
173	58.1	64.0	68.3	160	46.0	50.6	53.0
178	61.9	68.6	72.4	163	47.3	52.1	54.9
183	[illegible]	73.3	77.8	165	49.1	54.1	57.3

Height/weight tables for Indian adults



The method of science

4

How can we use the method of science and seek answers to our questions?

Text© P M Bhargava

One can use the method of science for various purposes.

The method of science can be used to find answers to questions either by careful observation or careful analysis.

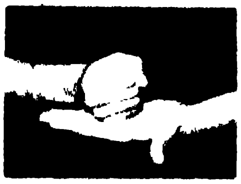
EXAMPLE 1

To find an answer to a specific question, when similar questions have been answered many times before

The sequence in such a case generally is

1. *Question*: Find out the density of a liquid at room temperature
2. *Experiment*: Weigh a known volume of the liquid on a double pan balance
3. *Answer*:

$$\text{Density} = \frac{\text{Observed weight}}{\text{Observed volume}}$$



The answer in this case is a SCIENTIFIC FACT

EXAMPLE 2

To find an answer to a question to which the answer is wholly or partially unknown.

The sequence here is

1. *The beginning:* an observation you have made or an analysis you have carried out of the existing knowledge
2. *Formulate the question* on the basis of the observation or the analysis
3. *Formulate a hypothesis* (the answer you consider most likely).
4. *Design an experiment* to test the hypothesis, and conduct the experiment carefully.
5. *Record the results.*

The results do not support the hypothesis (the answer you had considered most likely is not the right answer).	The results support the hypothesis (that is, the answer you considered most likely, could be the right answer).
	Modify the hypothesis

6. *Do more experiments.* The larger the number and variety of experiments supporting your hypothesis, the greater is the probability of your hypothesis being right.

   You are likely to have arrived at the right answer when no further experiment can be done which would disprove your hypothesis.
7. *The end* (when you have found the answer). If your answer was of a general nature and of wide applicability, you could formulate a GENERALISATION-for example, a law. If not, you have arrived at a fact.

The above sequence is followed in scientific research.

EXAMPLE 3

To find an answer to a question under conditions where an experiment is not possible.

The sequence is.

1. *Frame the question* (the question could be in the form of a specified objective desired to be achieved).

   What shall I do to have my brother, who is suffering from typhoid, get well as quickly as possible?
2. *Frame various possible answers* (the hypothesis).

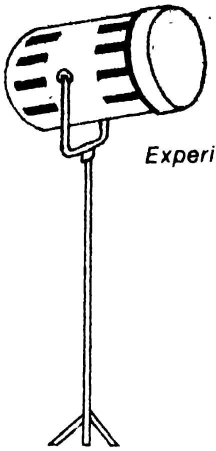
I should go to a place of worship and pray for him;
I should let nature take its own course, and hope for the best;
I should give him an extract of certain commonly used spices recommended by a friend;
I should seek the advice of a competent doctor trained in modern medicine.

3. *Determine which answer would be most compatible with existing knowledge.*

   After careful thought and analysis, I conclude that only the last mentioned course of action is in agreement with existing knowledge and is likely to cure my brother. I, therefore, decide to consult a competent doctor trained in modern medicine.

The method of science can be applied in this manner for answering questions pertaining to a vast range of human activity—from decision-making in daily life to ethics, politics, economics and human behaviour.

An example of the application of the method of science

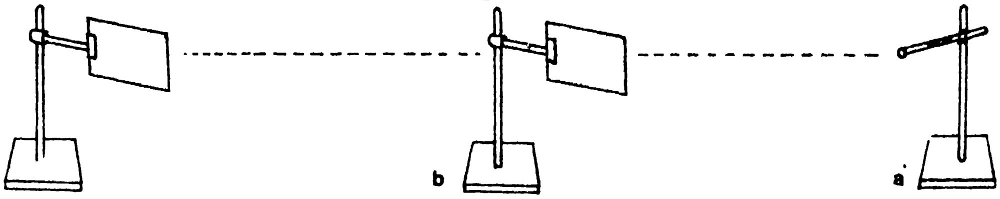


Question: **What is the path followed by light?**

Hypothesis: **Light may travel in a straight line.**

Experiments: 1. If light were to travel in a straight line, the light-source 'a' should be visible through hole 'c' when the source 'a' and holes 'b' and 'c' are in a straight line.

2. The light-source 'a' should not be visible through hole 'c' when the source 'a' and holes 'b' and 'c' are not in a straight line.



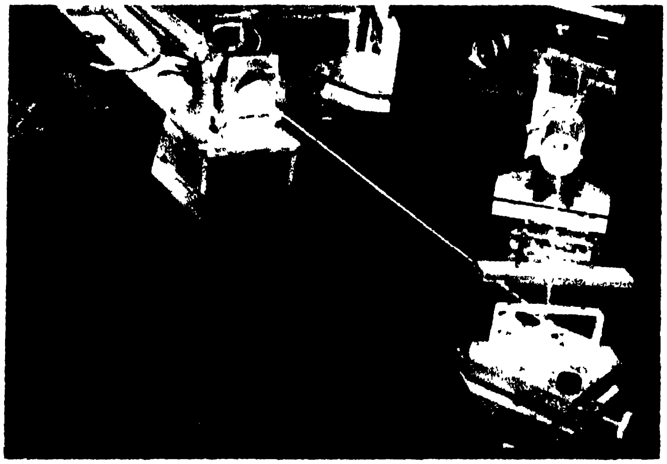
To do the experiments, we should collect·

- a point source of light
- two cardboard sheets with pin-holes
- a stand suitable for the light source and the cardboard sheets
- a scale

Please note that this experiment cannot be done if any one of these items is taken away.

Another experiment:

One can arrive at the same conclusion—that light travels in a straight line—through many other experiments. For example, in the case of the laser beam shown here, one can 'see' the light travelling in a straight line. Therefore, we may now formulate the law that light travels in a straight line.



CAUTION

Please note that the above law would be expected to hold true only for the conditions used in our experiments. For example, in these experiments light travelled in a uniform medium (air), and the accuracy of our measurements was small (say, 0 05 cm) You would find that the above law breaks down if,

a uniform medium was not used for the light to pass—for example, if cardboard 'b' was placed in between two glass sheets,

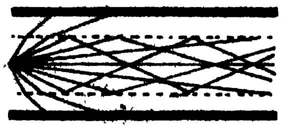
we could measure and align distances with an accuracy of 0.00001 cm.

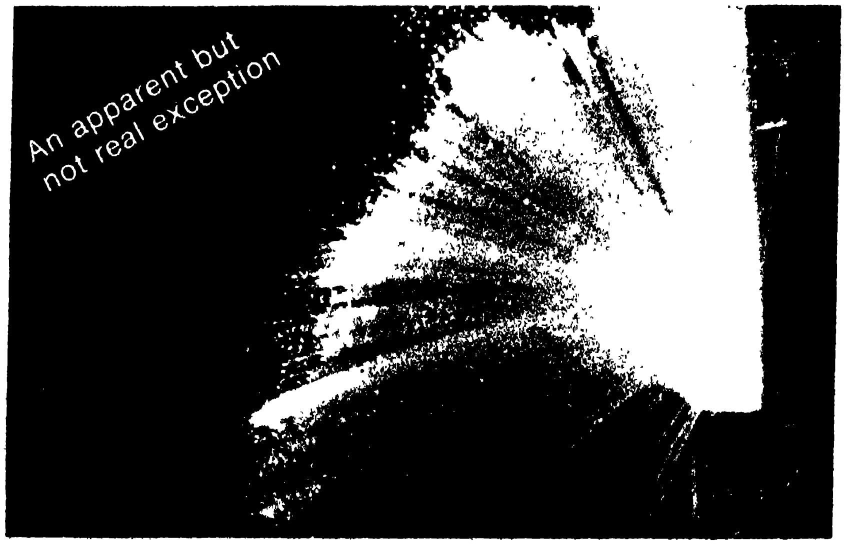
We may, therefore, also conclude that when stating a law, it is important to define carefully the conditions under which the law may be expected to hold true.

At times light may appear to travel in curved lines, as in the case of fibre optics at right. Note the light at the tip of each thin, spaghetti-like fibre: it comes from the bulb, following the curvature of the fibre.

Explanation in terms of the law we just enunciated:light from the bulb undergoes a series of total internal reflections and follows the path illustrated below.

This case is, therefore, not an exception to the law that light travels in a straight line.





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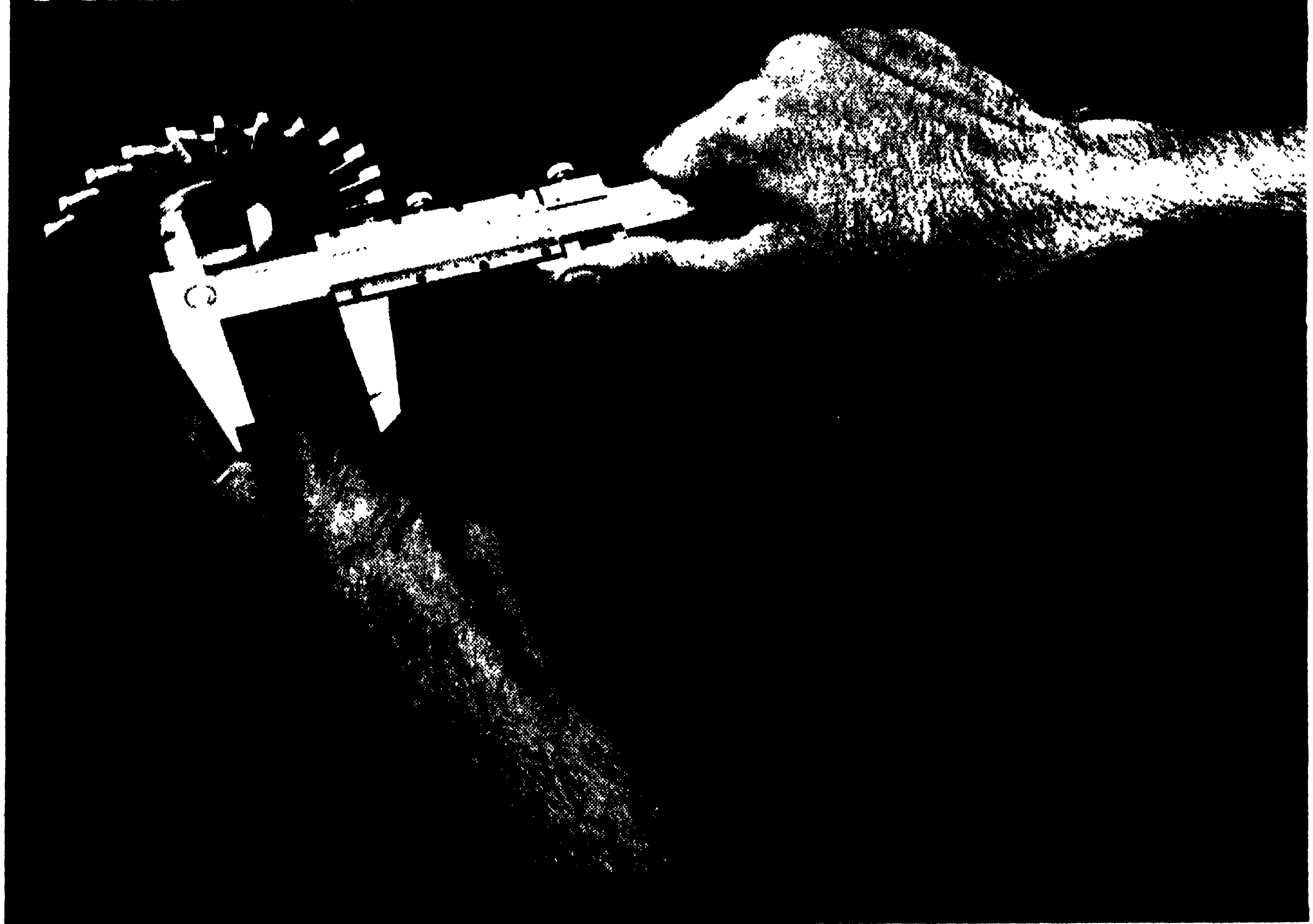

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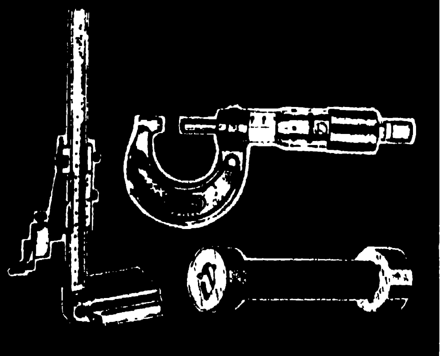

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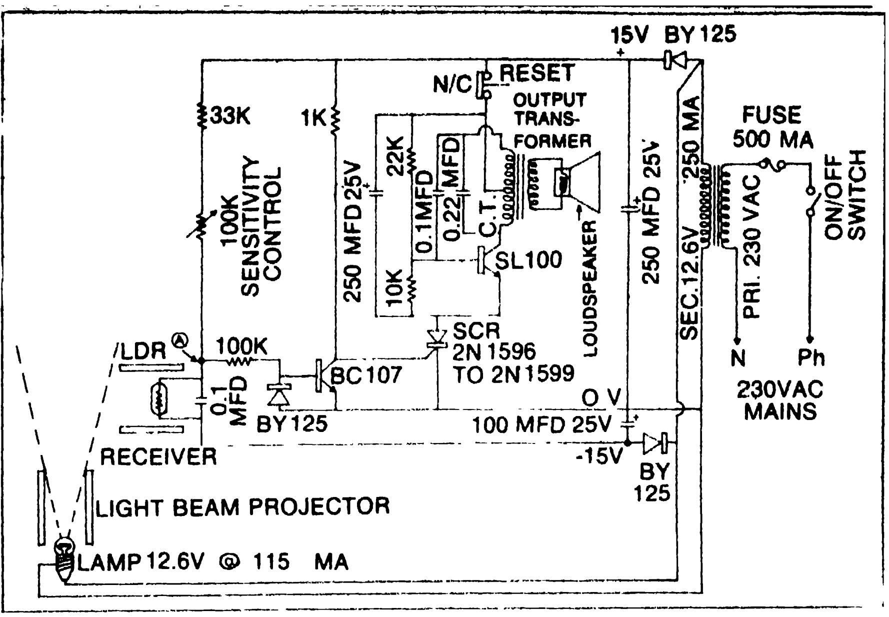
Smoke Alarm

THERE cannot be smoke without fire. Here is a device using a simple electronic circuit which detects the smoke and give out an audio alarm. Once started the alarm continues with or without the smoke till the reset push button is pressed. This smoke detector has to be installed very close to the ceiling, since smoke is generally lighter than air and thus first accumulates near the ceiling.

The lamp as well as the LDR are installed inside tubes having inside diameter of approximately 15 mm. The length of both the tubes is approximately 100 mm. Both the tubes, projector and receiver, are kept at right angles to each other, as shown in the diagram, such that the LDR does not receive any light, either direct or reflected. The whole assembly, including the light beam projector and LDR receiver are enclosed inside a suitably vented wooden, plastic or metallic enclosure, which though allowing smoke to get in, will offer sufficient obstruction to any external light source interfering with the LDR. To avoid the internal reflection of light from the light beam projector, the enclosure and the projector-receiver tubes have to be painted, inside as well as outside, with black matt paint. When the smoke enters the enclosure, it interrupts the light beam and the light gets reflected in all directions. Some part of this reflection illuminates the LDR and the device produces an audio alarm.



The LDR, along with the 22K resistor and sensitivity control potentiometer forms a voltage divider. This voltage divider is connected between positive and negative 15V supplies. The sensitivity control potentiometer provides the necessary sensivity control adjustment for the device. The variation in the resistance values of the LDR, due to changes in its illumination, causes the corresponding change in the voltage division provided by it. The placement of the LDR in this device, as explained above, is such that normally it will be almost in complete darkness. Thus, the resistance offered by it will be of the order of a few megohms. This will make the common point of the LDR and the sensitivity control potentiometer, marked 'A' in the diagram, to approach the positive 15V supply. When the LDR gets slightly illuminated due to reflection of light from the smoke, its value will drop down very much. This considerable drop in the resistance value of the LDR will drive the common point 'A' towards the negative 15V DC supply.

As the common point 'A' is connected to the base of the transistor BC107 through the 100K resistor, the transistor remains in conduction till the common point provides positive voltage and keeps the gate-cathode circuit of the SCR shorted. When the LDR gets slightly illuminated by smoke, the negative going common point 'A' voltage cannot keep the transistor in conduction and sufficient

How the silicon controlled rectifier works

THE first practical semiconductor device was a rectifier diode. The diode is made of two layers of semiconductor material. The transistor, which came next, has three layers of semiconductor material and three electrodes. The transistor can be used as an amplifier or as a switch.

The next stage of development was a four-layer, three-electrode device called silicon controlled rectifier (SCR); also known as thyristor. The three electrodes are called anode, cathode and gate. The SCR combines the action of both rectifier and transistor in a single device. As rectifier, it converts an alternating current to a direct current, and as an amplifier a small triggering signal applied to its gate can switch it on to pass a very high rectified current from the anode to cathode.

An ordinary rectifier conducts when its anode is positive with respect to its cathode. [illegible] [illegible]tive. Thus, the current available through the rectifier is always unidirectional, that is, DC. The SCR differs from an ordinary rectifier in many ways. When the gate of the SCR is not triggered, the SCR won't conduct in either direction. It will conduct, provided a triggering voltage is applied, at least for a moment, to its gate, while its anode is positive with respect to its cathode. The SCR will not conduct if the triggering of the gate is done while its anode is negative. Once the SCR conducts, that is, current starts flowing from its anode to cathode, it behaves as an ordinary rectifier till its anode is at positive voltage. The gate no longer has any control over this anode current. In short, the gate can only make the SCR conductive. It can't make the conducting SCR non-conducting. To make a conducting SCR non-conducting, the anode current passing through it must be interrupted, at least for a moment, by some external means. After this, if once again the anode is made positive with respect to its cathode, the SCR will not conduct unless its gate is triggered once again.

The SCR is very fast in its action. It hardly takes a few micro-seconds, when its gate is triggered, to become conducting from the non-conducting gate. This duration is called 'turn on time'. To make it non-conductive, a current cut-off duration of a fraction of a millisecond is sufficient. This duration is called 'turn-off time'.

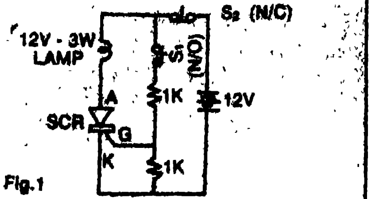


Fig.1

The simple circuit shown here will give a clear idea of SCR operation.

The lamp will light up when push button S1 is pressed for a moment (triggering the SCR gate). The lamp will remain lighted till the push button S2 is pressed (to cut off the current through the SCR to make it non-conductive). The lamp will not light again though the push button is released. The lamp can once again be lighted provided the S1 push button is pressed again.

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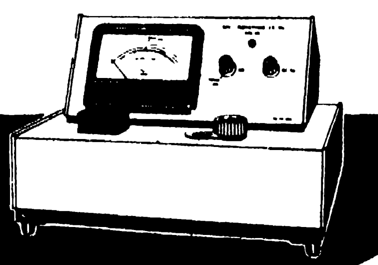

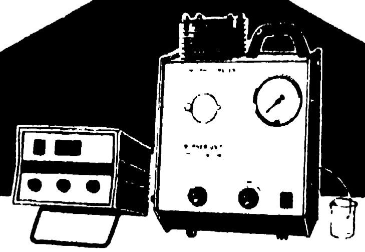

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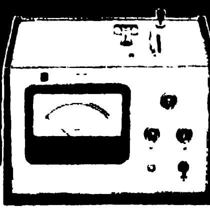

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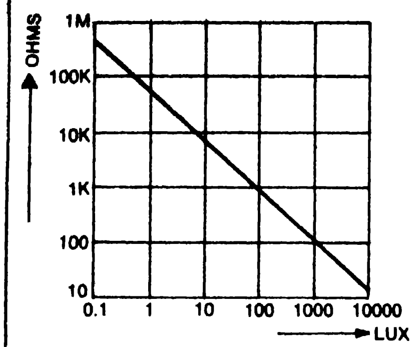

LDR CHARACTERISTICS

current flows through the 1K collector resistor to the gate-cathode circuit of the SCR. This triggers the SCR, which comes into conduction. As you know, by triggering the gate-cathode circuit, the SCR can be brought into conduction, but the gate-cathode circuit has no control over the SCR which is already in conduction. To turn the SCR from conducting to non-conducting state, the anode current must be interrupted at least for a fraction of a second.

The single transistor audio oscillator is used to provide an audio alarm. The complete audio oscillator circuit is connected as an anode load for the SCR. Thus, the SCR, when in conduction, starts the audio alarm and once started the alarm can only be switched off by pressing the normally closed reset push button, that is, by anode current interruption.

Note: The device explained above is the modified version of the "Smoke Detector" (SCIENCE TODAY, November 1973).

You will need:

Semiconductors: SCR 2N1596 to 2N1599 or any 1 Amp 100V SCR - 1 No. LDR - 1 No. Transistors, BC107 or BC108 or BC109 - 1 No.; SL100 - 1 No. Rectifier Diodes, BY125 or BY126 - 3 Nos.

Capacitors: Electrolytic: 250 mfd - 25V - 2 No; 100 mfd — 25V- 1 No. Polyester or ceramic: 0.22 mfd - 1 No.; 0.1 mfd - 2 Nos.

Resistors (all ½ watt): 100K - 1 No.; 33K - 1 No.; 22K - 1 No.; 10K - 1 No.; 1K - 1 No.

Potentiometer : 100K carbon linear or wire wound - 1 No.

Loudspeaker: 8 ohms 500 mW type - 1 No.

Output transformer: Push-pull primary matching with transistor SL100; Secondary 8 ohms. - 1 No.

Approximate cost of the above components in Bombay market, Rs. 95.

Mains transformer · Primary: 230V AC, Secondary; 12.6V 250 mA.

Misc: Normally closed pushbutton - 1 No, fuse 500 mA with holder, ON/OFF switch, tubes to construct light beam projector and receiver (see text), knob for sensitivity control potentiometer, 12.6V - 115 mA lamp with holder - 1 No, solder, wires, suitable enclosure, black matt paint, screws, etc.

ANIL V. BORKAR

Brain Teasers

School Fees :

In class X of a school, there are 9 boys and 16 girls. If the fee paid by each boy is different from the fee paid by each girl student (due to their attending different courses) and the total monthly fee of the class is Rs. 220, how much does each girl student pay every month? The fee paid by each student is an integral number of rupees.

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(Solution next month)

Solution to last month's Brain Teaser

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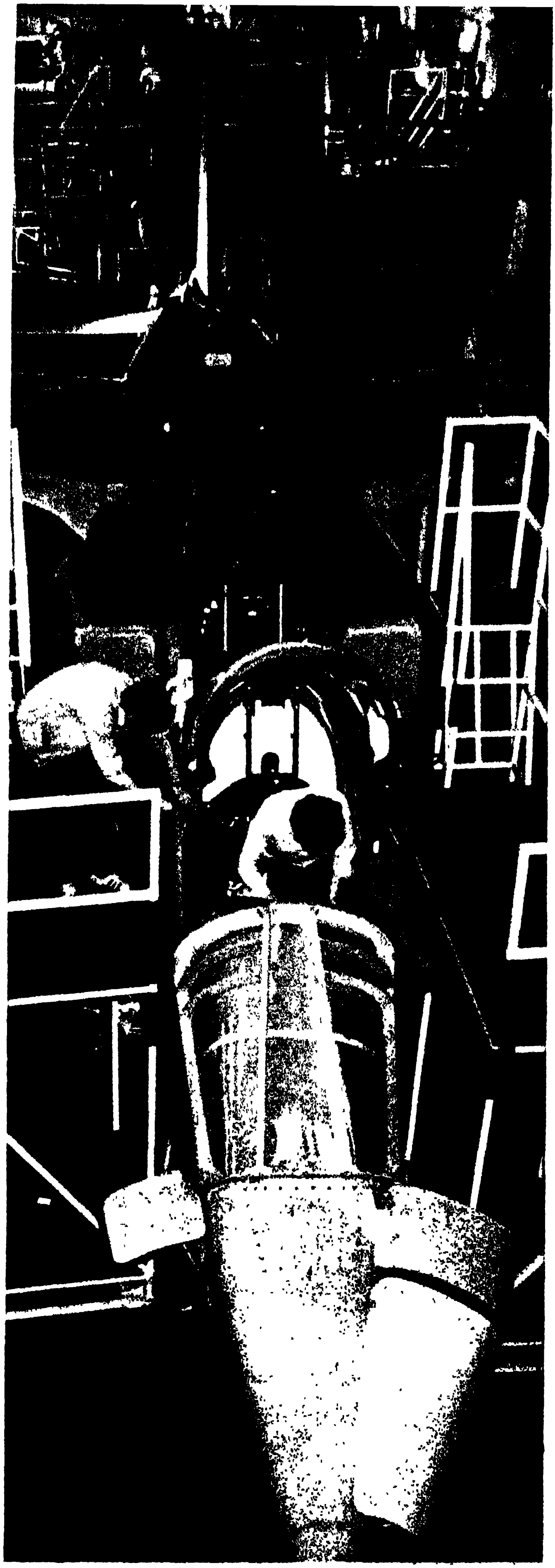

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Rugged and straightforward. Although an advanced, supersonic aircraft, with very sophisticated systems, Jaguar is structurally rugged and straightforward. This not only makes it straightforward to manufacture but also gives it high resistance to battle damage. Its dependability and survival ability are further enhanced by duplication of the main systems, self-sealing fuel collector boxes, protected feed pipes and twin-engine configuration

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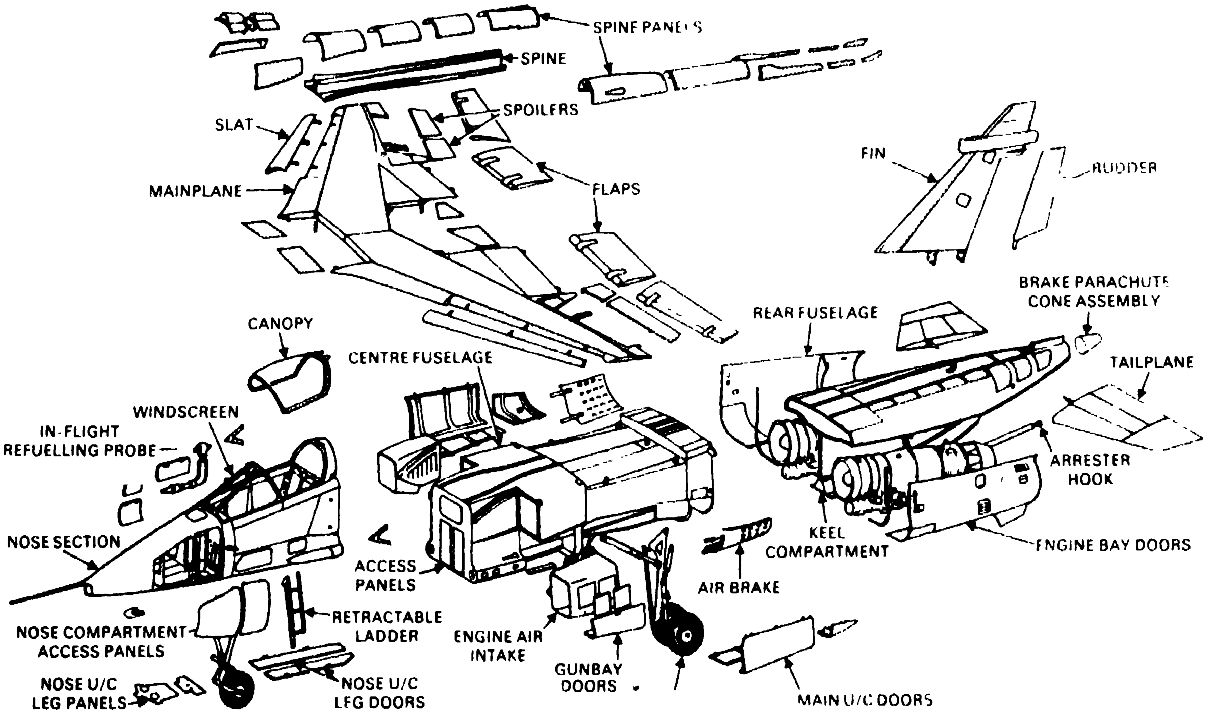

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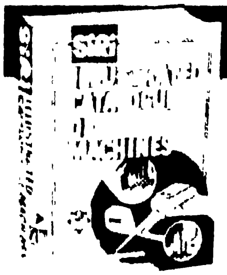

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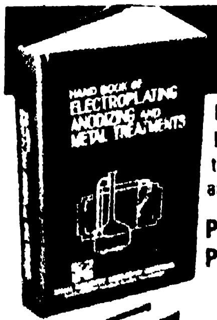

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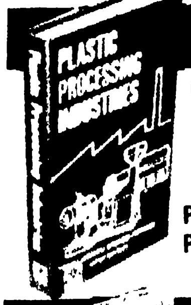

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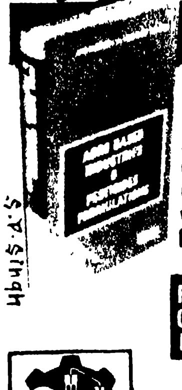

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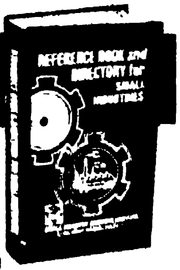

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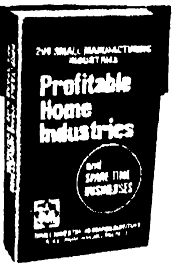

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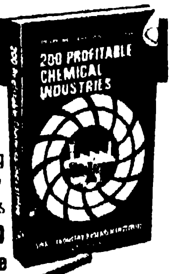

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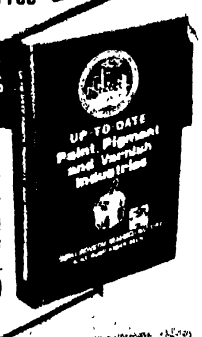

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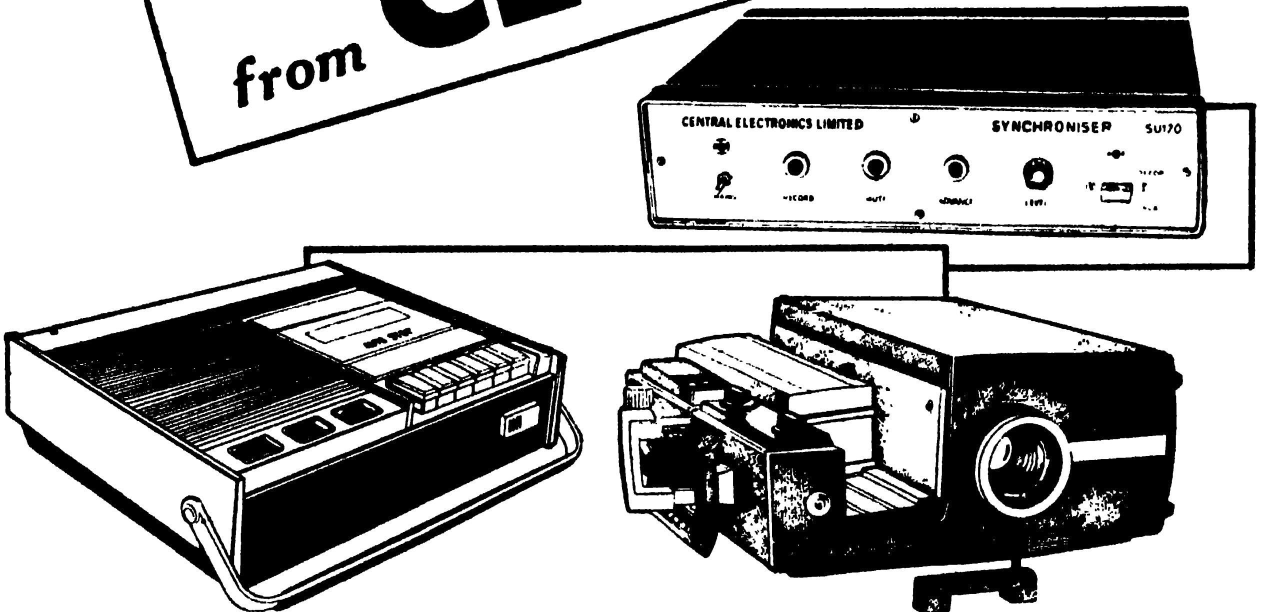

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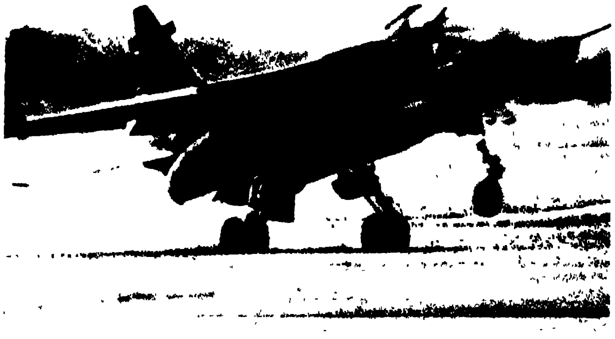

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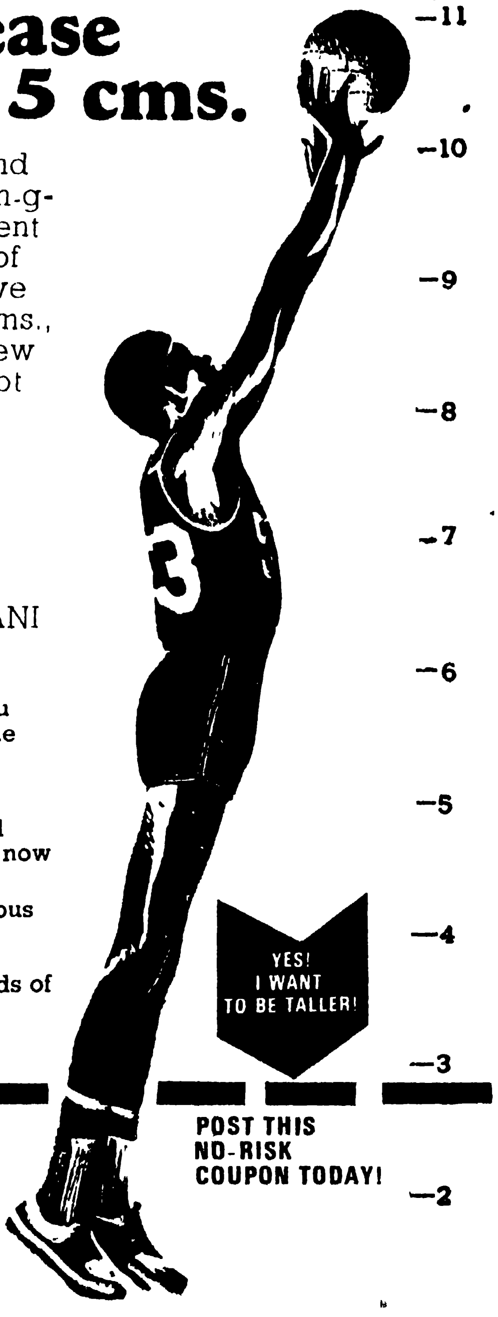
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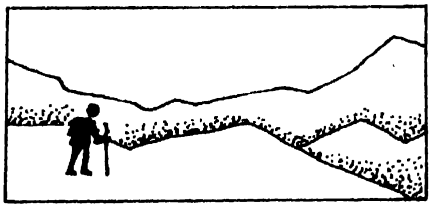
Science Today

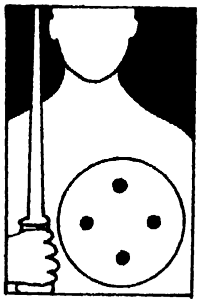
May 1980 Vol 14 No 5

24 **Celestial rings**
J C. Bhattacharyya
A major astronomical discovery from India discussed against the general background of planetary rings and their significance

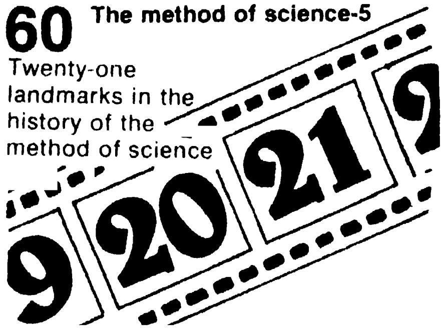
44 **A peek into Silent Valley**
Unique denizens of India's only remaining tropical rain forest



50 **The defence of the body**
G P. Phondke
The immune system is a remarkable mechanism for spotting out and combating "foreigners" in the body

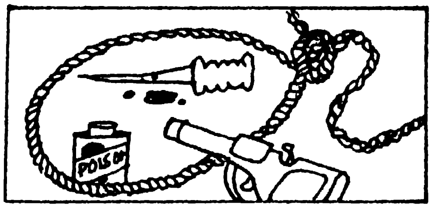


60 **The method of science-5**
Twenty-one landmarks in the history of the method of science



66 **How thermal stress affects workers**
Krish Pennathur
What should industrial managers do when the mercury shoots up and workers' output comes down?

68 **The cause of death**
Pritam P. Phatnani
The means used by the killer may provide clues to the investigator



7 Letters
9 Viewpoints
17 View from New Delhi
19 Blurs and Bright Spots
21 Science Shapes Life
31 Round-up of Research
35 This World of Science!
35 .. and of Scientists
36 Another Window
43 Ideas and Inventions
47 If .
49 Books
49 Brain Teasers
57 Quiz
57 Awards and Appointments
63 Fun with Mathematics
64 Tell Us...
70 You Too Can Do It

9 Scientific temper and public policy
17 Cover-up at Tarapur
19 Monsters and myths
36 How to take science to the masses?
47 If Planck's constant had a different value
63 Polyominoes
64 How do birds build nests?
70 Automatic twilight lamp

Cover photo David DeSouza

Editor:
Surendr Jha

Editorial queries are to be addressed to the Editor, SCIENCE TODAY, Times of India Building, Dr D.N. Road, Bombay 400001. Unsolicited articles must carry adequate return postage.

Single copy: Rs 2
Subscription. 1 year Rs 20;
2 years Rs 39, 3 years Rs. 58

Subscription queries and payments should be addressed to the Circulation Manager, SCIENCE TODAY, Times of India Building, Dr D N. Road, Bombay 400001.

Printed and published for the proprietors, Bennett, Coleman & Co , Ltd , by T P Pithavala at Usha Offset Printers Pvt. Ltd , 125, Govt Industrial Estate, Kandivli, Bombay 400 067 General Manager Dr. Ram S. Tarneja. Branches: 7, Bahadurshah Zafar Marg, New Delhi 110 002 139, Ashram Road, Ahmedabad 380 009, 105/7A, S.N. Banerjee Road, Calcutta 700 014 Offices at 13/1, Government Place East, Calcutta 700 069; 63, Montieth Road, Egmore, Madras 600 008, 407-1, Tirath Bhavan, Quarter-gate, Pune 411 002, 26, Station Approach, Sudbury, Wembley, Middlesex, London, U.K London Tel. 01-903-9696

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ECLIPSE BLUES

SCIENTISTS of this country indeed failed in their duty by not opposing the propaganda machinery and not educating the people about the correct astronomical aspects of the February solar eclipse (Blurs and Bright Spots, March 1980). On the contrary, many self-styled ones joined the fray and made unfounded predictions about the adverse effects of the eclipse on plants, animals, and man. Some of them announced crude and unscientifically designed experiments to be conducted even in the regions of partial eclipse. They have committed the heinous crime of depriving Indians of a unique natural spectacle that attracted scientists and tourists from all over the world.

D. N. Misra Raj
Head, Botany Department
Government College
Khargone 451 001 (M. P.)

"And what a shame, nobody cared to study human behaviour during the eclipse..."

IT WAS shocking to find that the people of India should be victims of such baseless scare-mongering. The most amusing part of the story was that nobody dared to protest, not even our renowned scientists. If such is the attitude of Indians in spite of education, I think, we should delete the word 'Science' from our dictionaries.

Souvik Mukherjee
4, Anand Palli
Lucknow 226 002

AIRSHIPS

AN AIRSHIP (Science Shapes Life, March 1980) could have more advantages. For one, it will be difficult to hijack an airship, the main reason for a hijacker's success with a conventional aircraft being the near certainty of a total loss of life if he himself is willing to risk his life. For another, a substantial part of an airship's power source could be solar energy, as, with its vast surface area it would accommodate enough solar cells for electricity generation.

G. V. Padhya
CC/25/C G8 Rajouri Garden
New Delhi 110 064

SODD'S LAW

IN 'Why Do Things Go Wrong?' (Blurs and Bright Spots, February 1980), Sodd's Law has been stated and illustrated by two examples. Though the rigour of statistics and logic is not to be expected in this article which has been written in a light vein, I would like to bring to your notice the inability of the second example to illustrate Sodd's Law:

The rare (actually, the single noted) occurrence of the entrapment of the spring-loaded ball of the socket drive tool is perfectly in accordance with the negligibly small chance of the ball loosening and taking the right trajectory to enter the combustion chamber via the small spark-plug opening. However, this particular event (of removal of spark-plugs for cleaning and refitting) being of no preferential significance (over the periodic spark-plug cleaning for this car and for all cars) to the motorist concerned, the occasion cited does not [illegible] to substantiate the law.

Such a situation does not of course arise in the Kariba Dam example, because the water level was not of significance to the engineers every year as against that particular year when it was of crucial importance. This example thus satisfies the conditions of Sodd's Law.

Aseem Chandawarkar
6/165/E Dr. Ambedkar Road
Dadar, Bombay 400 014

DOUBLE QUASAR: A GRAVITATIONAL LENS EFFECT

THE QUASARS 0957 + 561 A and B (Round-up of Research, November 1979) are so close together that the question was raised whether they were two distinct objects or they just seemed to be double due to the gravitational lens effect. Now, astronomers at the Hale Observatories, USA (Gunn *et al, International Astronomical Union Circular* 3431) using the large 200-inch telescope have found a galaxy between ours and the quasars at a distance roughly one-third of that to the quasars. This, they suggest, is the object providing the gravitational field for the 'lens' producing the two images. On the basis of calculations, they predict that the B component of the quasar should itself be seen as two components with a much smaller separation. Observations are being attempted to confirm this prediction.

Krishna M. V. Apparao
Associate Professor
Space Astronomy Group
TIFR, Bombay 400 005

ELECTROMAGNETIC INDUCTION

ALTHOUGH Faraday is credited with the discovery of electromagnetic induction (Basic Forces of Nature and Their Unification, January 1980) it was Joseph Henry who had actually discovered it much earlier. Only, he was reluctant to publish the results of his discovery due to lack of adequeate experimental data—a feature typical of Henry.

After Faraday published his discovery in 1832, Henry also published the results of his experiments which included the findings on self-induction—a phenomenon which Faraday was unfamiliar with until the spring of 1837 when the two wizards of electricity met in England for the first time.

S. Dutt
Visveswarayya Regional College of Engineering
Nagpur 440 011

MORE ON PRIMATES

THE BOX along with the article "Primates in Trouble?" (December 1979) mentions only Karnataka and Tamil Nadu are having the Nilgiri langur. But they are also found in appreciable numbers in the evergreen forests and sholas of Kerala. Besides, the lion-tailed macaque is reported from Tamil Nadu also.

It seems the primates are the animals least studied and most persecuted by humans, although they have much in common with us.

B. Venugopal
Calicut University

L. Namassivayam
Science Centre
Calicut 673 002

ROLE OF SUGARS AT GENIC LEVEL

IT HAS long been known that the growth of fungi may be influenced by the addition of sugars in the culture media (Sugar, the Wonder Molecule, February 1980). Prof. P. N. Mehra in his 'gene-block hypothesis' a decade back, had proved that fern plants, when grown in test tubes, could be developed into gametophytes or sporophytes by the addition of sugars. This explains the role of sugars at genic level.

Sugars influence the gene expression directly by switching on or blocking a particular segment of the DNA and controlling the growth and differentiation of plants.

Arun Misra
Prof & Head, Botany Dept
Mithila University
Darbhanga 846 004

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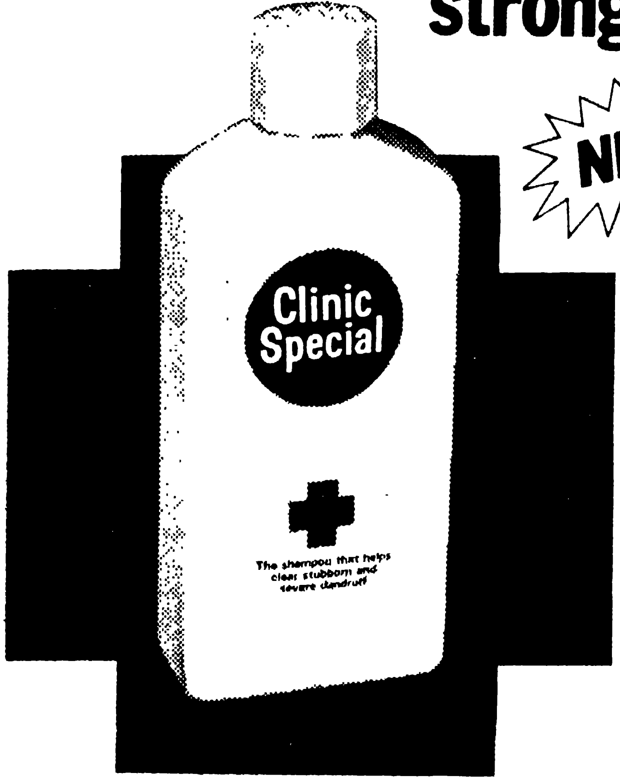


Scientific temper and public policy

THE vital role of science and technology (S and T) in development has been recognised in India since independence, and over the years, a large network of research laboratories and universities has been built up. India now has about 900 research institutions, including universities. The stock of S and T manpower in India is now estimated to be over two million —the third largest in the world. This base has enabled India to make significant progress in agriculture, health, atomic energy, space and other areas. It has also helped build a capacity to manufacture a wide range of industrial products. In fact, India now ranks among the first ten industrialised countries in the world and Indian scientists and technologists are making important contributions to development projects in many developing countries. India can, therefore, no longer be considered underdeveloped from the point of view of the availability of trained manpower, or technological and industrial capability. Many feel that it is poised for a take-off.

Yet the country remains largely poor and illiterate. It also continues to be dependent on imported technology, despite the oft-proclaimed slogan of self-reliance. *The new vitality and new dynamism characteristic of a civilisation propelled by S and T are yet to be seen.*

What has gone wrong? Is it because the new tools of thought represented by S and T have yet to permeate our society? Is it because our system has yet to absorb the spirit, the essence, the temper of science, and to learn to create adequate policy instruments to ensure that the growing S and T infrastructure gets harnessed to fulfil the national socio-economic objectives?

The development of scientific temper among the masses has often been discussed. Here, we will discuss scientific temper among the elites. For, the elites have a very considerable influence on the scientific ethos or temper and the value system in a society; they, in fact, set the pace. We shall not, however, discuss personal beliefs in astrology, godmen and miracles. Such non-scientific beliefs are, of course, known to exist among elites, including some scientists. They do affect the scientific temper in society at large, but this aspect too has been discussed. We will confine mostly to the problem of *scientific temper among our decision-making elites,* in so far as it affects decision-making in matters which affect national development, relating to the optimal use of our S and T infrastructure in particular.

What is scientific temper?

The dictionary defines the word tempering as bringing (clay, etc) to the desired *consistency* by moistening and kneading; and for metals, especially steel, or for glass, as *toughening and hardening* by heating, sudden cooling and reheating. *Temper* is the property so acquired. I would like to emphasise *consistency, toughness and hardness,* and the process (or ordeal) which the material has to go through in order to acquire these properties.

Scientific temper implies basically a scientific or rational attitude and approach to the understanding and solution of problems—acquired purposefully and maintained consistently and toughly in the face of disturbing forces. The essence of a scientific attitude is an active, sensitive, questioning and understanding, and creative relationship between man and his environment; not only the physical and biological environment, but also behavioural, social and cultural. It is a rational approach to the discovery of truth, through free and creative thinking, experimentation and objective analysis, and a steadfast commitment (with humility, not arrogance) to scientifically established truth. At the same time, it recognises the tentative and continuously unfolding character of our scientific understanding of phenomena.

Scientific approach also involves a deliberate effort to distinguish between apparent and real causes of phenomena and disentangle the different forces and motivations at work; a consistency between theory and practice; quantitative as distinguished from vague qualitative thinking; a spirit of adventure, a willingness to follow up a promising path or paradigm, consistently and tenaciously, to its logical conclusion with built-in consistency checks, and a willingness also to give up the paradigm if contradictions show up. An important characteristic of a scientific approach to the solution of problems is a systems approach—analysing the totality of a complex system into its essential components, and taking operational steps, making allowance for the mutual interactions of these components, so that the desired results may follow.

But science thrives on free communication and free availability of information; codification of experience; a willingness to take calculated risks, to make mistakes, to analyse them and to learn from experience; and a spirit of self-confidence and self-reliance. The existence of an invisible college of peers is another pre-requisite for the healthy growth of science in any country.

Some of the aspects of scientific temper most important in relation to public policy are: an awareness of what S and T can do in various sectors, and of the conditions under which this is possible; a systems approach; a clear understanding of inter-relations between policies in different sectors; an ongoing analysis and codification of experience to help in the definition of future strategy; openness to discussion and review of policies by experts in the field; free availability of information for this purpose; a recognition that for socially desired action to take place, mere exhortations and pious enunciations of policy are not adequate and that they have to be accompanied by appropriate policy instruments which take account of existing socio-political or motivational constraints; and finally, a commitment to make deliberate efforts to change the environment in which S and T function in the country—on the one hand, by taking calculated risks, if necessary, to promote indigenous technology and self-reliance, and, on the other hand, by actively promoting changes in the value system of the S and T community, so that S and T may be encouraged to play a more active role in problems of development.

A considerable responsibility to promote the scientific temper rests with the elites and their institutions, through a commitment which is reflected in consistent action. That this is not easy is illustrated by the sad history of the 'Method of Science' exhibition assembled for the National Council for Educational Research and Training (NCERT) under the direction of Dr. P. M. Bhargava, a distinguished scientist at the Regional Research Laboratory, Hyderabad (SCIENCE TODAY, January 1980, p. 47). As the name implies, the exhibition was planned and prepared with the idea of conveying the method and spirit of science to the general public. The NCERT, however, seems to have had afterthoughts, apparently because some panels were considered objectionable or controversial. It decided not to show the exhibition to the public after it was set up at Bal Bhavan, New Delhi, in early 1977.

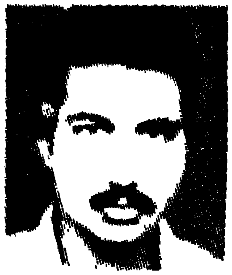
Scientific temper and planning

India has adopted planning as a mechanism for defining its develop-

MEDICAL ENTRANCE

Sunil Kumar Bansal

1st in Medical Entrance Delhi '77



Raghavendra Goswami

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[illegible] development projects and monitoring their implementation, so as to maximise development out of the limited resources available. Planning is much more than the mere articulation of aspirations and objectives. In effect, it is a scientific approach to mustering and co-ordinated use of resources and their allocation to meet the desired socio-economic objectives. But even after almost 30 years of planning, our society has yet to assimilate the scientific temper and the imperatives and discipline of planning. It has yet to realise that scientific planning demands a much clearer vision of the kind of society to be aimed at, a long-term commitment to achieve that objective, medium-term planning of a series of steps towards achieving the long-term goal, and a reasonable insulation of the planning and implementation process from the vagaries of the political situation and the exigencies of electioneering. If the financial situation is tight, it calls for a more careful husbanding of resources, and correspondingly, a more effective planning discipline and not a 'plan holiday'. A stop-go attitude to planning, with the Planning Commission sometimes assigned to the limbo, or confusing pronouncements about a rolling plan, and the failure to finalise a plan almost two years after the announced date of its commencement—these are inconsistent with the commitment to scientific planning.

The need for an S and T Plan as an integral part of the national socio-economic plan was recognised around 1970. This led to the creation of the National Committee on Science and Technology (NCST) in 1971. The NCST brought out a National S and T Plan (1974-79) in 1974, based on a critical study of 24 socio-economic sectors. The fate of this plan hangs like a ghost whenever S and T planning is discussed today.

The Draft Five-Year Plan 1978-83 has a chapter on S and T which discusses the factors responsible for that fate. It also discusses the steps that need to be taken if S and T planning and implementation are to be effective, in relation to the twin objectives of the S and T policy: (i) to secure for the people, particularly those in the rural areas, all the benefits that can accrue from the use of S and T, and (ii) to strengthen and harness the national S and T capability for enhancing self-reliance.

S and T planning has two aspects: (a) planning *for* the support of S and T, and (b) planning development *through* S and T. Planning for S and T has to be in a *long-term perspective* (10 to 15 years) in view of the substantial lead time between the start of any research and development effort and its fructification into a product, process or service. Also, the scale of investment in research and development for the absorption of imported know-how, for improvement of products/productivity/services, and for the development of new products and processes in any sector has to be commensurate with the scale of economic/service activities in that sector, its strategic importance, and the magnitude of change desired. One has also to ensure through appropriate steps that the expected benefits from S and T do actually materialise. Moreover, such efforts have to cover a wide spectrum of national activities and many of them cannot be covered by any of the major scientific agencies or departments.

A stop-go attitude to planning, with the Planning Commission assigned to the limbo, or confusing pronouncements about a rolling plan, and the failure to finalise a plan almost two years after the announced date of its commencement—these are inconsistent with the commitment to scientific planning

In this context, the Draft Plan identified the need for an effective nodal mechanism within the Planning Commission and within the economic ministries, equipped to take responsibility for a number of functions so that S and T planning may become effective and get integrated with socio-economic planning. It identifies the various inter-related components of effective S and T and goes on to state that it would be necessary to set up small professional information and planning groups for S and T in each economic ministry, and that the mere transfer of some of the CSIR laboratories to the 'user' economic ministries which took place recently will not serve the desired purpose.

With such a depth-analysis, one would have expected the government to take expeditious steps to create the necessary policy instruments. But no significant change in the situation is to be seen almost two years after the analysis. Meanwhile, the Planning Commission itself continues to be poorly equipped for S and T planning. It has not had the persuasive power with the government to be able to implement what it has itself prescribed.

In the absence of such steps, it is fair to say that there is very little S and T planning in the country and there is very little correlation between R and D and investment decisions; *the first casuality is self-reliance.*

Scientific temper and self-reliance

The basic ingredient of self-reliance is a *swadeshi* spirit with a long-term perspective—a commitment to make maximal use of the scientific, technological and industrial infrastructure. One is encouraged in the pursuit of self-reliance by the fact that wherever specific challenges and tasks have been assigned to our scientists and technologists, they have been able to accept and fulfil them, for example, in the atomic energy area (indigenous fuel of high purity, fabrication of fuel elements, plutonium separation, the peaceful nuclear experiment at Pokhran, etc) or in space or certain aspects of agriculture, offshore engineering, etc. Wherever we have resorted to soft options, we have had problems.

Though we are among the ten largest industrial countries in the world, why is it that we repeatedly go in for 'collaboration' even with small European countries? Is it that we lack the know-how or we lack confidence and have not yet got rid of complexes from the colonial period? A perceptive British colleague recently remarked: "Having got rid of the cruder forms of colonialism, it is a pity you now voluntarily establish scientific colonial status."

Apart from the colonial syndrome, there are serious defects in the manner in which we sometimes approach projects with a high S and T content. Self-reliance demands that when purchase of technology is being negotiated, our R and D scientists must be closely involved in the negotiations from the beginning. Yet one hears of projects involving hundreds of crores of rupees, where the concerned R and D scientists were not involved in early negotiations. If R and D scientists are not involved *from the beginning* in detailed discussions of various performance characteristics, design and material specifications, availability of know-how and know-why, etc which have a bearing on the choice of technology and the strategy for its absorption, how can one expect to absorb the technology and indigenise it rapidly? On the other hand, there are situations where an expert, who has prepared a detailed technical report in a rapidly changing high-technology area, spending several years over the preliminary phases of the project, is not given the responsibility for implementing it, but someone else who has *no* expertise in the sophisticated field is asked to head the enterprise.

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Most of the problems relating to basic human needs and rural development can often be solved immediately with the use of existing knowledge ...
Politicians tend to blame the S and T community for the fact that benefits of S and T bypass the poor and rural populations. Without manifest political will, mere exhortation to scientists can be counter-productive

Large complex industrial undertakings should be headed by technical people with a broad perspective, who are aware of the world-wide trends in technology, and who understand the importance of R and D for absorbing any imported know-how and improving upon it, so that products may become competitive on the world market. Yet we have an increasing tendency to appoint career administrative and finance officers to head public sector corporations—on transfer, which may often be for a short period, until they get promoted elsewhere. *The heads of such undertakings have to be technical people, with a long-term commitment to the undertaking.* They should be provided with competent assistance from high-level administrative, financial and marketing officers, rather than vice versa.

There is a general tendency to get carried away by arguments of economy of scale, which are used to justify import of technology. While we certainly have to compress the time-scale of our industrialisation, from a period of about two centuries taken by the western countries to a few decades, we should not overlook the requirements of a phased organic growth in various technologies within the country, allowing for a minimum gestation period, and for the need to stabilise a technology and/or equipment and/or operational and maintenance experience at each of a few successive levels before jumping to the next level. Economy of scale must also not ignore the opportunity costs involved when technological capability and industrial capacity (for example, for capital goods) existing in the country, are not fully exploited and are not allowed to expand at a healthy rate in relation to expanding demands. One must also not ignore its likely impact on the morale of R and D institutions as well as industry if these capacities are not optimally utilised—one of the causes of brain-drain.

Essentially on these grounds, the Sethna Committee had recommended in May 1977 that in respect of fertiliser plants, 900 tonnes per day of ammonia be considered as an optimum figure. Within a few months, however, the government took a decision to go in for 1,350-tonnes-per-day plants, apparently on grounds of economy of scale. One wonders what is the mechanism by which the government processes the recommendations of such committees.

The prime contract for these big fertiliser plants based on the Bombay High gas has reportedly been given to a foreign company. One is not aware of any meaningful involvement of an Indian consultancy and engineering design organisation that would ensure rapid absorption of the foreign technology and thus lead to self-reliance. The fertiliser industry provides an interesting case of the tragedy of our dependence on foreign aid and imported technology in a vital area. In fact, recently there has been a resurgence of a tendency to give turn-key jobs or prime contracts to foreign companies; the tendency to ask foreigners to make feasibility reports also persists, even when local expertise has been built up in many areas. In this context, it is not clear if the expertise in the petrochemicals area generated within the Indian Petrochemicals Ltd (IPCL) and Engineers India Ltd (EIL) through the giant IPCL project at Baroda is being adequately utilised for the projects at Bongaigaon and Haldia. Or is one likely to repeat the errors made in the case of fertilisers? It is also difficult to understand why an old foreign technology is being preferred to an alternative offered by a national laboratory for a low-temperature carbonisation plant, especially when a reputed national consultancy and design engineering organisation has reportedly been willingly to provide guarantees for the indigenous route.

A question which often bedevils discussions relating to the use of indigenous technology is that of "provenness"—when can one accept it as "proven"? Obviously, a certain amount of calculated risk will have to be taken when one builds any plant for the first time in the country. Such risk can often be taken safely by slight overdesigning—which turns out to be cheaper in the long run when several plants are to be built. Should the country not take such a 'risk' at least when an experienced consultancy organisation is willing to provide guarantees? If necessary, one can always secure back-up support from an overseas company, during the transition period. This has been successfully done in a few cases, but has yet to become part of our national strategy for self-reliance.

It is time to look closely into the role of aid, technical assistance programmes and loans from international financing institutions like the World Bank, and of international careerism, in distorting our perspectives and policies and undermining our self-reliance. Such aid often forces us, directly or indirectly, to commission outsiders to make feasibility reports, and to buy capital goods from abroad, thus slowing down the pace of growth and confidence of our capital goods industry. In particular, *the practice of inviting global .tenders looks pernicious.* Developed countries give a strong preference to their own capital goods, and use the home market base to launch an invasion of foreign markets.

Often one hears an argument, "what is wrong with competing?" Competition may be alright if it is on fair and equal terms; but big transnational corporations, with their large turnover and global links, can often afford to make bids which an emerging local industry finds it difficult to compete with; it is *unscientific* to prefer a foreign technology on the basis of a marginal advantage (on paper) of being a few per cent cheaper, when there are so many uncertainties about cost-escalations, possible difficulties in the use of local materials and operation and maintenance under Indian conditions.

It may be instructive to remind ourselves that even after the industrial revolution had started in England, England found it necessary to protect itself against Indian textiles on the one hand, and also to force British textiles on the Indian market, to keep down and strangle a competitor with whom it could not have competed on equal terms. As the historian H.H. Wilson has observed, "Had this not been the case, had not such prohibitory duties and decrees existed, *the mills of Paesley and Manchester would have stopped in their outset and could hardly have been again set in motion, even by the power of steam.* They were created by the sacrifice of Indian manufacturers."

But we do not seem to learn from history. For example, there are reports about the possibility of an American firm being allowed to come in a big way into the Indian solar energy market if a proposal made to the Government is approved (SCIENCE TODAY, January 1980, p. 12). These have aroused a considerable concern among Indian solar technologists who naturally feel that the venture will kill indigenous efforts in solar technology.

Informed peer system

Earlier, I referred to the existence of a peer system as one of the pre-

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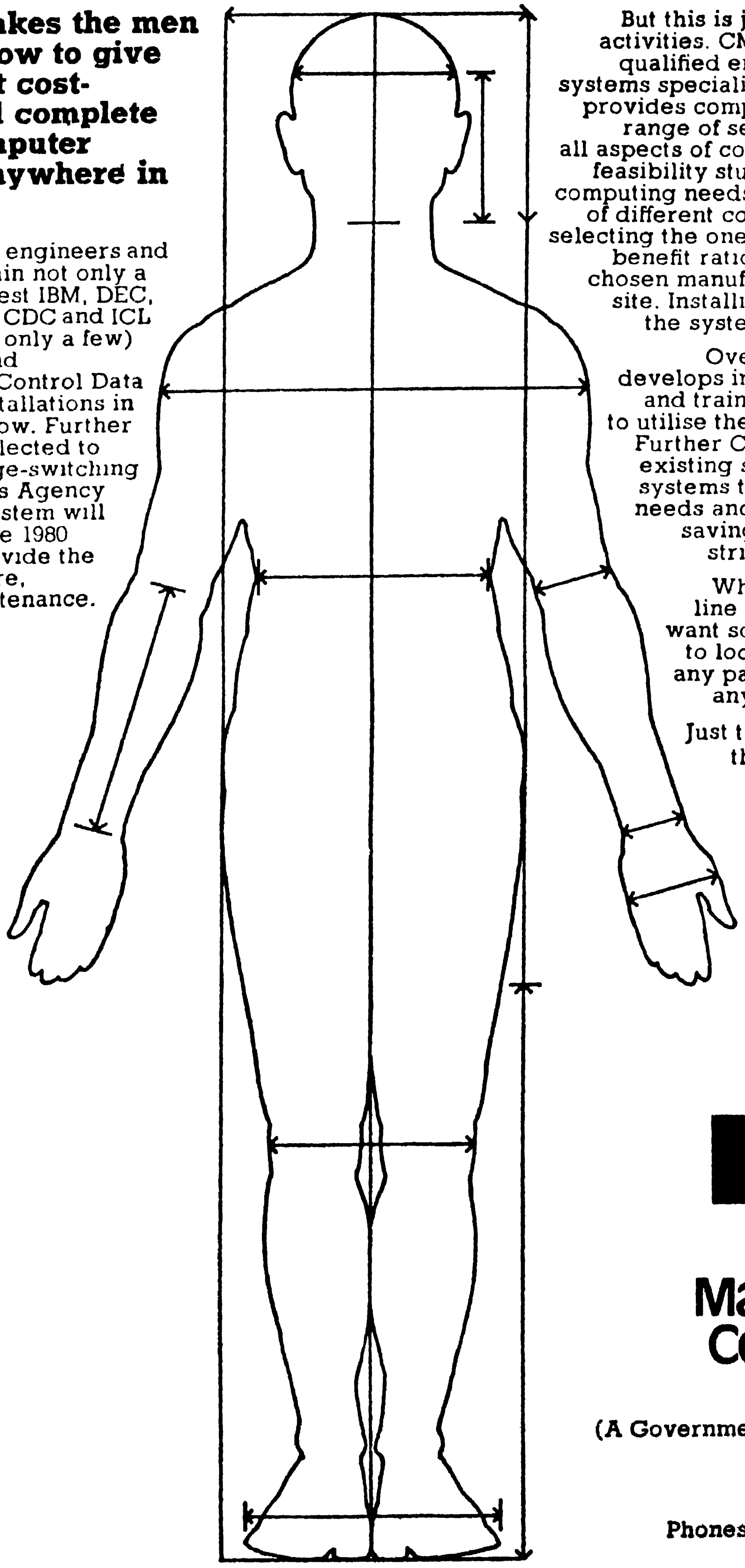

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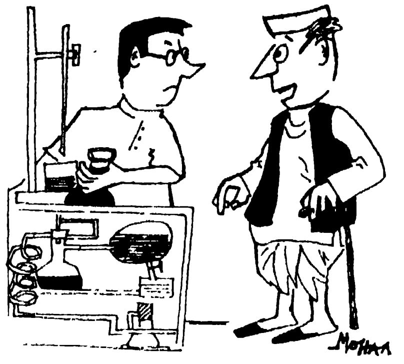
requisites for the healthy growth of science. Peers can function only if they have free access to all relevant detailed information. Can one have such a peer system operating in our country in respect of public policy decisions, even those involving S and T policy, when it is so difficult to have access to information, even between two government agencies? As an example, one may mention the recent debate regarding the proposed umbrella-type collaboration agreement between the Bharat Heavy Electricals Ltd and Siemens. The only information available to the public was through the booklet written by Mr. P. Ramamurthy, an MP, and a few stray articles in magazines by disturbed BHEL engineers. Very serious issues having a bearing on the long-term technology policy of the country in an important sector were clearly involved and also questions related to the morale of R and D scientists at BHEL and elsewhere. Yet no authentic information was available to scientists and technologists in the country on the basis of which they might have discussed the merits of the case dispassionately. In fact, one gets the impression that the proposal would not have received the scrutiny it did at the official level, but for the political dimensions introduced by Mr. Ramamurthy's booklet, and the discussions in Parliament.

S and T for basic needs

Most of the problems relating to basic human needs and rural development do not demand research and the generation of new knowledge, though new knowledge may certainly help. Often, they can be solved immediately, by and large with the use of existing knowledge, possibly with some adaptation. Correspondingly, more than anything else, they call for socio-political commitments and adequate resource allocations without which existing knowledge cannot be used—for example, rural water supply, or combating nightblindness, or dehydration due to gastroenteritis (which is one of the greatest killers of children), or malnutrition. This aspect needs emphasis, since politicians tend to blame the S and T community for the fact that benefits of S and T bypass the poor and rural populations. Without manifest political will, mere exhortation to scientists can be counter-productive.

There is, however, an aspect of the problem where the academic community has to take some steps. This relates to changes in the value system within the academic community—giving due recognition to high quality work on taking science to the community. The responsibility is, however, not entirely with the scientific community at large. It also rests, perhaps even more so, with the decision-making elites, heads of R and D laboratories and scientific agencies and those who run the elite academies. In this context, the policy decision of the University Grants Commission that extension be considered as a third dimension of academic programmes in universities, equal in importance to teaching and research, is a significant step. This has to be followed up by individual universities. Some major R and D and educational institutions have taken steps to recognise such community-oriented activities, for example, through the creation of the Homi Bhabha Centre for Science Education at the Tata Institute of Fundamental Research, Bombay, or the Cell for the Application of S and T to Rural Areas (ASTRA) at the Indian Institute of Science, Bangalore. But the acceptance of such activities as legitimate by the scientific community and even more so by those who should finance them has been a painful process even in such prestigious institutions.



"I came personally to assure you that your needs have been recognised right from independence. Just wait a few more years."

CSIR and rural development

About a year and a half ago, the Planning Commission made a substantial specific allocation to the CSIR for programmes involving the delivery of S and T to rural areas. The CSIR appointed a committee under the chairmanship of Dr. B. D. Tilak to prepare a scheme for this purpose. The committee submitted its report over a year ago. Among other things, it recommended that the CSIR should take a definite policy decision to ask its laboratories to undertake and/or intensify R and D programmes specifically aimed at rural development, *in addition to* the on-going programmes. This would be similar to the UGC policy decision mentioned earlier. *We are not aware of any such policy decision having been taken by the CSIR.*

In the absence of such a policy decision, involvement through individual motivation and initiative may not be encouraged. And given the value system of the academic community, the involvement of CSIR laboratories in problems of rural development is likely to remain by and large marginal. A scientific approach to these challenges would appear to demand that scientists motivated to devote part or all of their time to rural problems must be encouraged by assuring them that such work is considered to be a legitimate activity in their laboratory, and that significant contributions in this area will be taken into account in career advancement.

The committee had also recommended that scientists in a laboratory who are so motivated should be constituted into a Rural Development Cell, with a specific budgetary allocation at its disposal, so that the Cell may be able to undertake action-research and field work in rural areas. One hopes that this recommendation too will be accepted by CSIR authorities before long.

Highly motivated individuals will, of course, always find a way of doing things in spite of the system. Such individuals serve as beacons. What we are discussing is the possibility of a rapid change in the ethos, and of lowering the threshold barrier, so that a large enough number may think of devoting part of their efforts to rural development problems. This requires policy decisions and manifest encouragement from the top. Mere exhortations will not serve the purpose.

To conclude, our system has repeatedly failed to show the strength to create effective policy instruments necessary to fulfil the desired objectives. Is this due to the lack of scientific temper or due to structural limitations of a dual society where so many conflicting interests come into play? One can only hope that the imperatives of a civilisation based on science and technology will themselves force our society to break out of its structural constraints. Meanwhile, for the various instances mentioned earlier, I would put the responsibility, not on individual elites but on the system of which they are a part and the environment in which they operate. In any case, within the government, responsibility and accountability are usually so diffuse that hardly anyone is accountable for not taking timely action.

B. M. UDGAONKAR

Prof. Udgaonkar is a senior professor at the Tata Institute of Fundamental Research, Bombay. This article is adapted from a paper he presented at the International Seminar on Science, Technology and Society in Developing Countries, Bombay, in November 1979.

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The 'leak' that leaked to the press

THE Department of Atomic Energy's (DAE) denial of press reports about the leaks in the Tarapur nuclear plant, the subsequent uproar in Parliament and the admission of a nuclear "incident" on 14 March reminded me of a cartoon captioning the following conversation between a technician of a nuclear plant and his boss.

Technician: "Sir, the coolant tube has started to leak."

Boss: "My god, don't leak it to the press."

The Tarapur leaks did leak to the press but what is astounding is the DAE secretary, Mr. H. N. Sethna's outburst against the media for having exaggerated the leak. Devoting a good part of his lecture at Baroda to a tirade against the press, he described reporters as "irresponsible," "self-styled experts" writing about things on which they lack even "elementary knowledge". The DAE's over-reaction to the press report appears to be a symptom of the malice afflicting the Department, and if the press reports were exaggerated, the DAE has to blame itself and the secrecy shrouding its projects.

The DAE's claim that it had never hushed up accidents has lost credibility in the light of the manner in which it handled the publicity of the 14 March accident in the coolant system of unit one at Tarapur. Radioactive water from the core gushing out of a 15-cm tube cannot, even by the DAE standards, be dismissed as a "pinhole" leak. The water drained into the reactor building when maintenance personnel were working. The water level in the reactor core began to fall and the emergency core spray had to be initiated to prevent the core from heating up. Meanwhile, a temporary plug was pushed inside the open tube to stop the leak by technicians who were showered by a spray of contaminated water. This plug should have been in a position where it could be immediately operated but, for reasons not known, it was not kept ready. This meant loss of time before the uncontrolled leak could be arrested. It is obvious that any basic safety requirements would have demanded a back-up device which, in this case, despite procedural requirements as specified by safety committees, was not maintained. And after the incident, the hapless technicians had to struggle. Was Parliament correctly informed?

Twenty-six persons were rushed to hospital in Bombay for a check-up and it was hinted at in Parliament that precautionary measures were taken to move the population, around the Tarapur plant, out. Two senior DAE officials were summoned to New Delhi on 19 March for a meeting with the Prime Minister, Mrs. Gandhi, who was obviously concerned about the incident. Despite all these, the DAE had kept mum.

Contrast this with the wide publicity given to the Three Mile Island (TMI) accident in the USA last year. Hours after the accident was announced, 300 reporters converged on the plant site. Official hourly bulletins were issued on the status of the reactor, and the plant's interior was televised. What happened at Tarapur was no doubt minor in comparison to the TMI disaster, but the DAE's silence throughout the week gives no assurance that it would be more vocal in the unlikely event of a major accident. One wishes that the DAE, which took a press party to Tarapur on 5 March, had arranged a trip on 15 March and allowed newsmen to interview the technicians in the hospital in Bombay.

Mr. Sethna was unfair in accusing the press of "imitating" western thinking on the environmental hazards of the Tarapur nuclear plant. The plant was imported from the USA, the engineers were trained in the West, and so why can't western standards be applied to evaluate its performance? The DAE officials also argue that accidents on roads and in coalmines occur more often than in nuclear plants. True, but the fact is those accidents are reported in the press. A gassy coalmine is closed and an explosion in a mine is followed by an official enquiry. It is only fair that the same rules of the game are applied to nuclear plants. Besides, the effects produced by the radioactivity released in a reactor accident are also of a genetic nature and are transmitted to future generations (and not only those which directly affect exposed persons and decrease their genetic fitness). These factors are not present in other accidents.

There are a few details of the 14 March "incident" that the DAE can clarify to restore its credibility. How much radioactivity leaked into the reactor buildings? What was the actual radiation dose registered by their film badges and dosimeters? The fact that most of the people do not know the definition of millirem and that ecology and environment are not the real issues in India should not deter the DAE from giving details. There have been persistent reports that Tarapur maintenance staff are overexposed to radiation. Doubts have been raised about the training of those personnel brought from outside the DAE to work at the Tarapur plant. One would also like to know how many modifications had been carried out at Tarapur following the analysis of the TMI accident. After the TMI accident all US power reactors are required to implement 175 "discrete actions" to ensure safety.

The apparent cover-up of the recent incident at Tarapur does not, however, belittle the achievements of the DAE staff in keeping the ailing plant running against heavy odds. Credit is due to the DAE engineers who have introduced innumerable modifications in the plant since its installation. It is an extraordinary act of bravery and dedication on the part of the technicians who stopped the gushing radioactive water on 14 March by pushing in a spare plug. The Indian press has highlighted every single achievement of the DAE, major or trivial. There will be no exaggerated reports on hazards and disorders of Tarapur plant, as alleged by Mr. Sethna, once the DAE lifts the veil of secrecy surrounding peaceful uses of nuclear energy.

Now that the DAE "appreciates the legitimate right" of the population in knowing about risks from nuclear plants, it may regularly publicise the radioactive pollution load of the plant's environment—water, plants, fish, etc. All routine reports, specially the health physics report, should be made public. Information is also lacking on how nuclear materials are transported from place to place within the country and how our nuclear wastes are disposed of. It may be recalled that people were told in advance and reporters were taken to the TMI plant recently when it carried out planned release of the accumulated krypton gas. The DAE may also allow the Central Board for Control and Prevention of Water Pollution, set up by an Act of Parliament, to monitor the environment of nuclear plants. All these will contribute to public education, and also to appreciation of what the DAE is doing. And an educated public will co-operate better with the DAE in times of emergencies and evacuation, if at all such a plan exists.

K. S. JAYARAMAN

Dr. Jayaraman is Science Correspondent of the Press Trust of India, New Delhi

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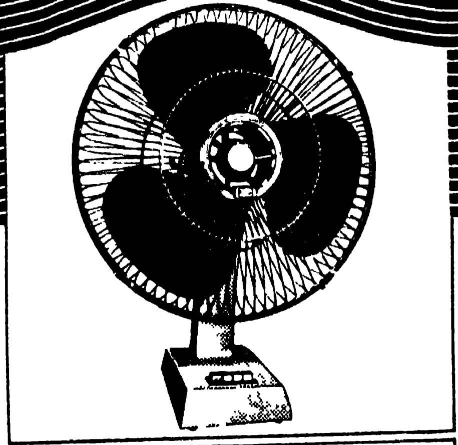

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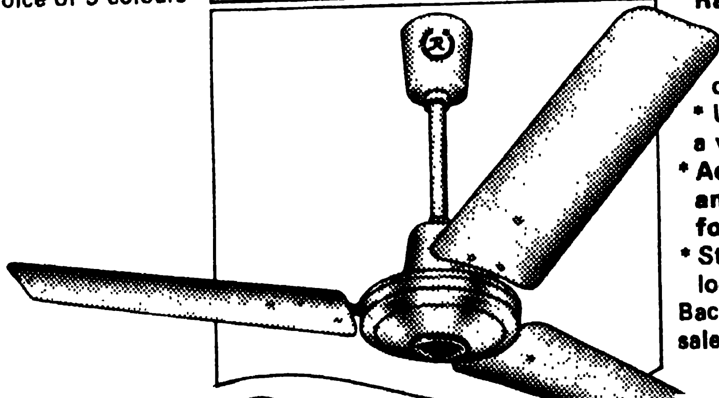

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- Sleek, elegant design results in silent, wobble-free operation
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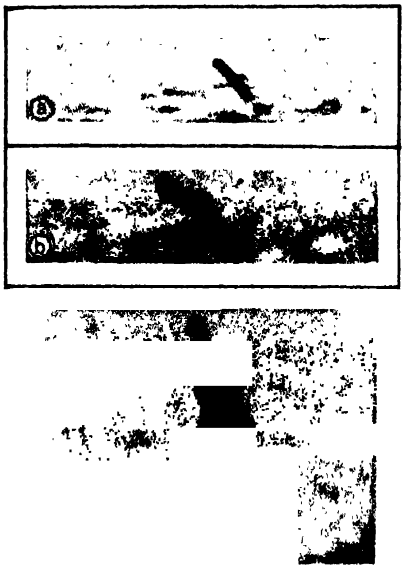
Monsters in limbo

COME SUMMER, tourists and naturalists will flock as usual to Loch Ness, Scotland, to look for the lake monster. Last year they trained a pair of dolphins to help in the search. But the mystery remained unresolved.

Why do monsters so fascinate us? Perhaps psychologists can tell. Monsters do fill our myths, legends and folklore. Look at the variety: cyclops, centaurs, common giants, dragons, chimeras and what-have-you. One of them, the fierce fire-spitting dragon from whom chivalrous knights habitually rescued damsels, had been listed as 'fauna known to science' until as recently as 1564 in the prestigious *Historia Animalium* of Conrad Gesner.

Could such creatures exist? Take for example, the giants. The common belief is that they were scaled-up models of man. However, according to the physical laws that govern shapes and sizes, giants of such proportions cannot exist (see SCIENCE TODAY, October 1977, p 15).

Monsterophiles are nowadays keen to bestow respectability on their pets and protect them from poachers. A double-barrelled 'scientific' name does the trick. No one has been able to trap a Loch Ness monster or even obtain its remains. Yet, it has been christened *Nessiteras rhombopteryx* (*Ness* comes from lake, *teras* means marvel or wonder, and *rhombopteryx* means diamond-shaped fins). The pre-requisite of zoological practice that, in naming a species, the specimen available or a selection of them must be preserved in the permanent collection of a museum, has not deterred the enthusiasts.



Stick after the squall has passed (a), and distorted images due to atmospheric effects (b and c)

Nessie has been heard of for centuries, but it shot into fame only after 1933 when a road was laid on the west bank of Loch Ness. The first claim of having captured it on film was made in 1934 by a London gynaecologist. That was adequate proof of its existence for many.

But, as in any other field, sceptics abound. Though not all have categorically denied its existence, some have put forward interesting explanations for the sightings. Most sightings have been reported in spring or early summer. Here is a classic example of a sighting: one cold dawn a man spotted Nessie as it raised its long neck from the calm water. Soon there was a squall and it sank. When the squall passed he looked again and saw a floating object. It was a stick. Where did Nessie vanish? During spring and early summer, the lake surface is much cooler than the air around it. Also, most sightings have been reported during calm weather. Such weather conditions can lead to atmospheric refraction that distorts images; things appear much larger than they really are and slight movements of water ripples give the object a swaying motion.

Was Nessie then just a stick? Whatever it be, the monster stories are good for Scotland's tourist trade.

Another monster waiting in the wings to be recognised is the abominable snowman of the icy Himalayan mountains and the arctic. Yeti, 'big foot' and 'susquatch' are some of its names in different regions. Here again, the creature, if it exists, is elusive. Just like Nessie. Many claim they have indeed seen a yeti and even photographed the monster and its footprints in snow. The interest is sustained because nobody has trapped one so far. A Nepali monastery has a scalp and hand bones which are claimed to be that of a yeti. Similarly, there are reports of a mummified yeti in Tibet. The yeti too is protected by law in Nepal and any yeti-seeking expedition must pay a royalty.

The so-called yeti's "footprints" in the snow are about 30 cm large and nearly a metre apart. Is it really a giant? Or merely a figment of man's wild imagination? As to the large footprints, one explanation is that melting snow enlarged impressions of human footprints.

The Sikkimese, who take the yeti for granted, believe it was born of love between an ape and a Chinese girl. Further north, in Siberia, they believe that the abominable snowmen are really members of a very primitive tribe, who retreated when the more advanced tribes invaded their territory.

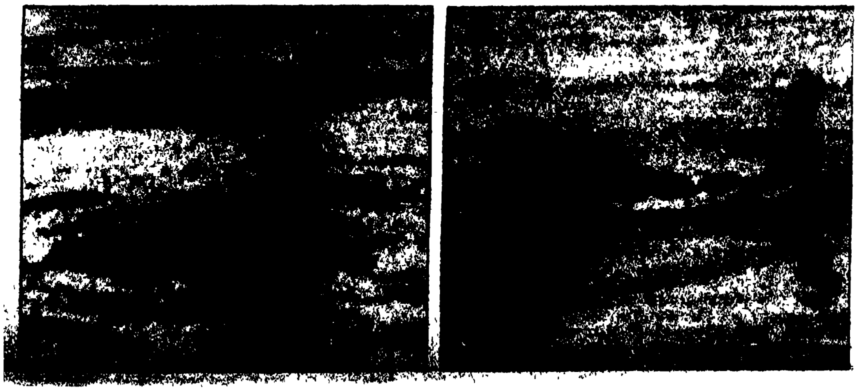
However, even in the choice of a monster, fashions and fads change. Today the hunt is directed outside earth. The word Martian conjures up a weird picture of a greenish biped creature, part reptilian, part human, part insect-like and all that. And then there are the UFOs, popularly known as flying saucers. One science magazine, *Omni* even runs a regular column on UFOs

So pick your monster according to your taste. You have a whole range of them—from the good old Nessie and yeti to the largest extraterrestrial beings—to choose from. The romantic common factor is that they are always waiting to be discovered.

SUMATI SAMPEMANE

Miss Sampemane is on the editorial staff of SCIENCE TODAY.

Nessie may be an elephant out for a swim. Just a minute. The figure on the left is the famous Nessie picture of 1934. Now Nessie, as described from the sightings, is dark-coloured with a humped back, long neck and small head. The other picture, which resembles the monster, is that of an elephant in water. Does that mean the first photo could also be that of an elephant? But then, how did the elephant get into the Loch? The only explanation so far is that probably travelling circuses took their jumbos there for a swim



Amazing reports of relief from gum trouble

Two of the many letters Forhan's users write of their own accord.

"Not only cleans teeth, but also has capacity to do away with dental troubles"

"...Whenever I myself or any other member of our family suffers from pain in teeth and gums, we apply Forhan's Toothpaste...the pain subsides in no time. Your Forhan's toothpaste not only cleans teeth but also has capacity to do away with dental troubles..."

(Sd/- Deepa Sharad Patwardhan, Bombay)

(Photostats of these and other such letters can be seen at any office of Geoffrey Manners & Co. Ltd.)

"...Helping to possess a sound gum..."

"I have no hesitation to use the superlatives about the quality of Forhan's, an ideal Paste for all, mainly for those who are suffering in gum troubles and with teeth.

In my college life I became a victim of gum troubles but my college physician advised to use the Paste which helped me and still now helping to possess a sound gum..."

(Sd/- Gour Kishor Chakrabarti, Burdwan)

Take care of your gums with Forhan's, the toothpaste created by a dentist

Dr. Forhan's exclusive formula

The powerful astringent action of Dr. Forhan's formula strengthens the gum surface to help you resist gum troubles.

Dentists say

Gum troubles can lead to the loss of even healthy teeth. So brush your teeth and massage your gums night and morning with Forhan's Toothpaste and Forhan's Double Action Toothbrush.

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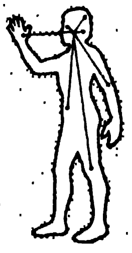
Gum troubles lead to health troubles



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Science Shapes Life

DRUG FROM HUMAN MILK?

Viral gastroenteritis claims some five million lives each year, most of them infants from developing countries. The most susceptible group of infants is the age group between five months and two years.

One causative organism, a wheel-like virus called the rotavirus, was first identified in 1969; four years later, it had been found in human faeces. The virus causes gastroenteritis by destroying the lining of the intestine and thus inhibiting absorption. This results in severe vomiting and diarrhoea.

Adults seldom get the viral disease; nor, strangely, do the new borns. What could be the reason? Jangu Banatvala and colleagues at St. Thomas Hospital, London, have traced the new born's immunity to breast-feeding. Breast-fed babies, they found, excrete small amounts of the virus in their faeces or none. The virus levels in the faeces of new borns were highest five to eight days after birth, yet these children rarely showed the disease. However, they often act as carriers and pass on the infection to their older sibs in whom it might prove fatal. Banatvala suggests that it is some factor in milk that protects the new-born babies.

This protective factor is not an antibody since the protection bore no relation to the quantity of antibody obtained from the milk. This led to the conclusion that the protective factor could be some non-specific substance or something in the cellular components of milk. If this factor could be pinned down, the scientists feel, it could be isolated and used to protect the older children since previous infection confers no immunity on them.

COMMON PLANT MAY HELP TREAT CANCER

Rubia cordifolia is a common plant found throughout the hilly districts of India. Known locally in Maharashtra and other states as *manjistha*, the plant has traditionally been used by villagers in treating cobra bites and scorpion stings. Its root is used in the preparation of a tonic and also in a dye.

Manjistha appears to have one more use, this time in modern medicine. M.K. Adwankar, M. P. Chitnis and colleagues of the Chemotherapy Division, Cancer Research Institute, Bombay, have found positive evidence for anti-cancer activity in the plant.

Extracts of the whole plant prepared in organic solvents were tested against experimental cancer in a particular strain of laboratory mice. Under normal conditions, an injection of 10^6 cells of the experimental cancer causes the mice to die in about nine to 11 days. But treated with a methanol extract of *manjistha*, the median survival time (MST) of the mice was increased up to 165 per cent compared to a control group. Also, a chloroform fraction of the methanol extract raised the MST up to 183 per cent.

This is significant, say the researchers, because if the ratio of the MST of the treated group to that of the control group is equal to or greater than 125, the test material is considered active and worthy of further investigations.

No toxicology tests have yet been carried out on the material and, hence, the possible side-effects of any drug preparation are not known.

PLASTIC COOKING VESSELS

You could put it on an electric hot plate and heat it to 300° C and it won't melt or char. Of course, they cannot be heated over a direct torch and would need some sort of a screen just like some glassware that need a wire gauze. To make them heat resistant, the vessels will have a composite bottom made of a graphite-based material laminated with plastic.

The process for making this new plastic heating vessel which has been developed by Intertec Associates Inc., a research and development firm in Rochester, New York, USA, lends itself to mass production.

Such vessels would have many advantages over the others—metallic and glass—used currently. They could be made non-corrosive by using corrosion resistant plastic. Also, unlike glass, these vessels will be able to stand knocks and falls since they will be unbreakable. High conductive thermal materials, if used in the composite, could make the vessel heat up quickly and thus save on fuel. Also, the composite bottom does not expand too much and so there is no warping; thus the area of contact with the burner remains unaffected and increases heating efficiency.

From the number of manufacturers who have shown interest in the process, it appears plastic heating vessels will soon become a reality.

NOW THEY ARE LAUNCHING A CLOUD

And the cloud will be green. Seen from earth, it will look slightly larger than the moon. Scientists at West Germany's Max Planck Institute for Extraterrestrial Physics are planning to launch a cloud of barium 64,000 km above the equator in June this year. The barium will ionise to produce the green moon which will be used in magnetospheric studies. The cloudy green moon once secured in its place will be visible in the European sky and from parts of Africa just after sunset.

FLOWER GUARD

There is the story of how a Russian Czarina had posted a guard to protect a flower that had bloomed in a remote corner of her palace gardens. The flower died away but the guard stood rooted to the spot year in and year out, not knowing what he was there for. Flower guards are back in action, now in Britain, to protect a rare species of orchids.

One rare species sought by thieves is the ghost orchid (*Epipogium aphyllum*). Last year only five ghost orchid flowers bloomed in Britain. Of these, two flowers were stolen and a third was trampled by sightseers. Ghost orchids are dug up and sold by orchid thieves to European customers who pay as much as £ 200 per piece. The courts can fine offenders £ 100 but no one has been brought to book so far since there isn't enough evidence for the prosecution.

Ghost orchid

The plant that merited the guard was the one and only plant of its kind in the British Isles—a lady's slipper orchid. The Nature Conservancy Council (NCC) has sponsored watchmen to guard the plant all through the day and night for a month each year when the flower is in bloom.

The only hope for preserving rare species like the early spider, late spider, military lizard and ghost orchids is to grow them from the seed. Experiments are being carried out at Kew Gardens, Monks Wood Experimental Station of the Institute of Terrestrial Ecology, and

Uttarpara

at other places. But so far, efforts to grow orchids from seeds have not been successful.

A GENE FOR BREAST CANCER

They have found it. It is on chromosome number 10 and it codes for the enzyme glutamatepyrurate transaminase. There are probably many other genes involved and a particular gene might run in one family while another in another family. Mary-Claire King at the University of California School of Public Health, studied several families, each with about 10 to 20 cases of breast cancer. Earlier research had shown a woman's risk of breast cancer increased if several of her close relatives had the disease. King and her team studied 150 cases extending over five generations. In 13 per cent of the families that King studied, the disease was consistently associated with the presence of the enzyme. The study confirms the theory of genetic susceptibility to the disease and rules out environmental and cultural practices.

What else does this gene do? King and her associates are trying to find this out. If they can identify the products of the gene, they might be able to tell how breast cancer takes root.

A POST-VASECTOMY EFFECT

Many researchers in the past have studied the trace metal concentrations in the sperm environment of patients with either low sperm count or poor sperm motility, and compared it to normal subjects. But how does vasectomy affect the trace metal concentrations?

The prostrate gland in man has been shown to secrete three major electrolytes containing zinc, magnesium and calcium, present in human semen. Besides, there has been the traditional belief right from the nineteenth century that vasectomy prevents prostatic enlargement, a serious ailment affecting over five per cent of men past age 60.

So, in an attempt to find any possible effect of vasectomy on prostatic function as well as to study the long-term effects of vasectomy on electrolyte composition, V. K. Naik and co-workers from the Institute for Research in Reproduction, Bombay, and the Health Physics Department, Bhabha Atomic Research Centre, Bombay, examined seminal plasma concentrations of zinc, magnesium, calcium, sodium and potassium in a group of 60 men in the age group 24 to 45 years who had all been vasectomised for periods ranging from one to eight years. The researchers used 22 normal fertile men in the same age group as controls.

Seminal plasma, separated by using a centrifuge, was diluted and analysed using a single beam atomic spectrophotometer. It was noticed that the mean concentration of zinc and magnesium were significantly lower (by ∽36 and ∽46 per cent, respectively) in the vasectomised group as compared to the fertile group. The trace concentration of calcium, too, was lower by a small amount (∽19 per cent). No significant difference was seen in the sodium and potassium concentrations for the two groups.

Based on this finding, the researchers speculate that vasectomy might result in decreased prostatic function, although it may not affect libido. However, it is not possible to say whether, on account of this, vasectomy could be beneficial to older persons, since no study has yet been made on the incidence of prostatic disorders in vasectomised men.

However, since the compositions of seminal electrolytes are known to affect sperm motility, a knowledge of such variations in vasectomised individuals could prove helpful to the many men who wish to have themselves recanalised.

SYNTHETIC LEAF

Scientists at the Battelle Laboratories, Ohio, USA, have reproduced for the first time in the laboratory a synthetic chlorophyll that behaves somewhat like the natural one.

In plants, pairs of chlorophyll molecules are attached to a protein complex. The Battelle scientists have produced a protein with one chlorophyll attached to it. This complex was able to absorb red light at the same wavelength as chlorophyll in plants.

The Battelle scientists substituted water soluble chlorophyll for the 'heme' portion (the red portion) in a protein called myoglobin which served as the base. (Myoglobin is a hemoglobin-like protein found in muscles.)

The new leaf, it is hoped, will help to understand the photosynthesis process and to develop methods to convert sunlight into useful chemicals. It might even help to harness solar energy to extract hydrogen from water.

PAYING FOR LIBERATION

Don't ask whether it is worth the price. After all, who would cherish bondage? Liberation at any cost, the libbers would insist.

Women, according to *The Book of Breakthroughs* by Charles Panati, published by the Houghton Mifflin Company, Boston, are losing the health advantage they have over men. The slightly longer life span women enjoy at present may soon even out. For example, peptic ulcer, considered a predominantly male disease, has risen among women who were previously not very susceptible to it. Blood pressure levels in women are also shooting up. And liberation has almost made it necessary for the liberated women to smoke; it has become one of the symbols of freedom. The price of this is the increased rate of lung cancer. According to the American Cancer Society as many women as men will die of lung cancer in the US by the end of this century. And then, it is well known that between adolescence and menopause women are protected against some kinds of heart disease. Now it has been found that 11

WORLD'S FIRST SOCIAL STRUCTURE

The remains of an ancient social structure has been discovered in southeastern Turkey. Excavated in the sixties, this building is an aesthetic and architectural expression of the cultural and social evolution of man in 7,500 BC. The people of Cayönu, where this monument stands, lived in small round hu ts then.

The remains show a large room with lower walls of stone, interior stone palisters, stone columns and a flagstone floor. A similar construction on an even larger scale dated at some two centuries later has been found in another part of the village.

What was the building used for? Researchers of the Chicago University, Istanbul University and the Institute for Architectural History in Karlsruhe, West Germany who excavated and radiocarbon dated this ancient structure think this might have been either a political forum or a place of worship.

per cent more women under 45 suffer heart attacks than before.

Evolutionarily, women probably had an edge over men in longevity because they were less expendable than men. Even at an early age, after they impregnated one or more women, men were dispensable. Not so the women; they had to be around to rear the offspring.

The health problems that women face due to their new social roles and the stress incurred by them have to be evaluated. For example, men produce more adrenalin than women when faced with stress. But probably this is a learned response. Women might begin to react similarly.

FREQUENT BREAST-FEEDING HELPS CONTRACEPTION

Women of the !Kung tribe in the Kalahari desert have a baby once every 44 months on an average. This gap between babies is quite large to be attributed to breast-feeding alone. However, no other factor seems to be involved in this desert bushmen tribe. Anthropologists have come up with some reasons like low nutritional levels and the long time spent in food gathering which leaves very little time for reproduction.

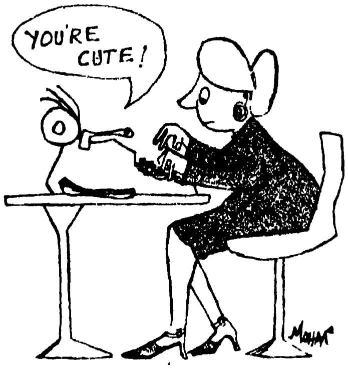
Melvin Konner and Carol Worthman of Harvard University have come up with a more probable explanation. This one too is based on breast-feeding. When a baby suckles, it stimulates the production of prolactin, a hormone that acts on other steroid hormones and prevents pregnancy by inhibiting ovulation. Normally, the prolactin secreted in response to suckling is rapidly destroyed and therefore, its inhibitory effect is also transient. However, !Kung babies suckle very often. The Harvard researchers found that they suckle for about 1.92 minutes every 13.19 minutes. And this keeps the prolactin levels continuously high. They may even suckle while the mothers are asleep at night.

Generally, breast-feeding mothers follow a strict regimen and feeding at will is rare and probably that is why this method of contraception is risky. There is no medical reason why a mother should not allow her baby to suckle whenever it wants to.

TALKING TYPEWRITER

Here is a typewriter that can speak and recite what it has just written. The voice of the machine is a synthesised sound. Developed by IBM, the new device can be attached to any of the four IBM magnetic media typewriters.

How does it talk back? As the operator types, a specific sound is produced for each key. The audioresponses are created by combining a set of basic speech sounds, called phonemes, in accordance with preprogrammed pronunciation rules that are stored in the machine's memory. These phonemes are blended to produce continuous speech.



The typewriter, meant for blind operators, has an audio keypad placed next to the keyboard to operate the audiotyping and to activate audioresponses. The talking typewriter which verbalises punctuation and capital letters even guides the operator about typing position on the page where it is reading from.

But stenos had better watch out. The next development will be typewriters you could talk to. Since voice recognition devices have become a reality, soon it will be possible to dictate directly to the typewriter.

ORGANIC SUPERCONDUCTOR

Superconductors are materials that offer no resistance at all to the flow of electricity. Certain metals like magnesium, zinc, cadmium, mercury, aluminium and lead become superconductors at low temperatures. Physicists had speculated that there might be certain superconductive organic materials too. A French physicist has now announced that he has found an organic superconductor. Denis Jerome and his team from Universite Paris-Sud and H. C. Oersted Institute, Copenhagen, cooled this material known as di-tetra-methyl-tetrathioselena-fulvalene-hexachlorophosphate $(TMTSF)_2\ PF_6$ to 0.9°K at a pressure of 12,000 atmospheres before they could make it superconductive. The material has passed the test of superconductivity: the flux lines of a static magnetic field passed around rather than through the samples of the compound.

For metals, 20°K is the upper temperature limit of superconductivity. Jerome thinks that by using higher pressures $(TMTSF)_2\ PF_6$ can be coaxed into becoming superconductive at 20° K. Probably there are other organic materials that could be made superconductive more easily around about 20° K.

The second part of speculations regarding superconductive organic materials is that they might retain the property above 20° K. This part of the speculation, it appears, is not going to be easy to realise. The day of room-temperature superconductors is still far away.

OZONE TO CLEAN TOBACCO

The most undesirable factor of cigarette smoke is the cancer-causing substance called tar. This black substance, which consists of various polynuclear aromatic hydrocarbons (PAH), gets deposited on the linings of the smoker's respiratory tract. Cigarette filters and tobacco substitutes are aimed at reducing this component from the smoke. But the results of such efforts are not satisfactory.

Now Dr. Abner Schepartz and colleagues at the Science Education and Administration's Tobacco and Health Laboratory, Russel Research Center, Athens, Georgia, USA, have found that treating tobacco with ozone causes PAH— producing components to oxidise and decompose so that less PAHs form. Phenols and nicotine in the ozonised tobacco samples are also reduced.

In their experiments the tobacco was suspended in water or methanol and then ozonised. Results showed that solanesol content fell by 44 to 100 per cent, certain fatty acids from 45 to 93 per cent and major sterols from 21 to 83 per cent. In other words, the PAH fraction reduces by 21 to 70 per cent. However, these are just the preliminary findings. The laboratory procedures will have to be modified considerably before safer cigarettes can be produced.

EYE OPENING NEEDLE

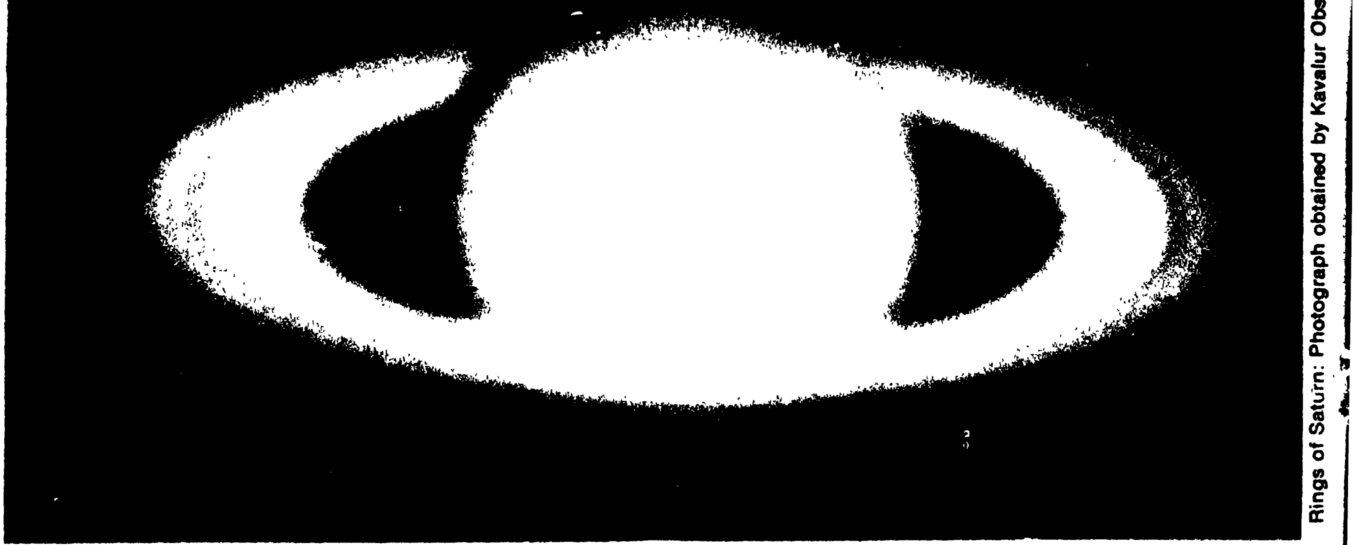
A Mexican inventor, Probert Pace, has patented a needle whose eye can be enlarged to thread it.

The needle consists of two high carbon steel filaments twisted and welded together at both ends. After the blunted end is welded, the filaments are given a three quarter twist and welded at the second end and given a point. Normally, the two filaments lie close together. To thread it, the needle is twisted slightly in the opposite direction and the eye opens. The needle gets back to shape when the pressure is released. Though it is made up of two filaments, the needle is as fine as the regular small-eyed one.

Celestial rings

J.C. Bhattacharyya

The study of rings around planets may help us understand how planetary systems form, says the discoverer of the rings of Uranus



Rings of Saturn: Photograph obtained by Kavalur Observatory, near Bangal

ONLY a few weeks back, the total solar eclipse watchers in India were spellbound by the brilliance of the diamond rings which appeared at the beginning and end of the totality. Though magnificent beyond description, these rings were in a way unreal. They were not really rings but an illusion created by the chance alignment of a lunar valley along the edge of the disc of the sun. But if with our telescope we scan the celestial panorama we will come across cases of several ring-like structures, of various sizes and forms. We will see the nebulous ring in the constellation of Lyra, or the clear well-defined rings of the planet Saturn. We can, using large telescopes, even photograph several other types of ring-like formations or deduce their existence from sets of well-planned observations.

The ring or disc-like formations in the universe are quite common. There are galaxies which are flat and disc-like, often with well-defined spiral arms. However they may have been formed, the role of the angular motion of the primeval gases is apparent in these objects because of the circular symmetry of their shapes. The preferred axes of rotation in the primeval gas clouds model their structure. In the process of contraction the form stretches out following the law of conservation of angular momentum which states that angular momentum can be transferred from one body to another, but it cannot be created or destroyed. Whether the system is a galaxy spanning thousands of parsecs, or a compact system stretching a few thousand kilometres, the same principle holds. It controls the shapes of the cosmic bodies.

Some of the ring-like objects seen in the sky are, however, only apparently ring-like. The ring nebula in Lyra is an example. All measurements show that its ring-like feature is really a near-spherical and nebulous glowing shell, but the projection effect transforms it into a nebulous ring in the sky plane (photo on p 25). By contrast the rings around the planets, like those around Saturn, are real annular-shaped stable features, held in place by dynamical forces of the planets and their other satellites.

Rings of Saturn

The discovery of the rings of Saturn by Galileo in 1609 was quite accidental. Looking through his tiny telescope, he noticed slight protruberances on the planetary disc and thought these to be two nearby bodies—companions of the planet. Better observing arrangements used by the Dutch astronomer Christian Huygens nearly half a century later showed them as rings encircling the planet. But the idea that this was a ring-like structure did not find acceptance easily. The feature was variously described as horns, handles or some appendages connected to the planet. Only when clearer pictures by bigger telescopes and under favourable observing conditions brought in unassailable proofs, was the ring structure accepted.

The intensive studies from ground-based telescopes over the past three and a half centuries have revealed that the planet is large compared to our earth, about 120,000 km in diameter and with a very noticeable flattening near the poles. The ring system, concentric with the planet, has three relatively bright members. These classically recognised rings are called A, B and C and are placed serially inwards from the bright visible edge. Between the rings A and B is a dark annular space, known as Cassini division. It is named after an Italian astronomer called Cassini who discovered it in the seventeenth century. A similar dark, although somewhat less prominent, zone known as Encke's division. is also noticed *inside* the outermost A ring. The B ring is the brightest, while the innermost ring C, or the Crepe ring, appears quite faint. Between the B and C rings is a gap which, although reported earlier by French astronomers using ground-based telescopes, was confirmed only recently by Pioneer 11 observations.

In recent years, large telescopes and refined measurement techniques have indicated two more faint rings—a D ring discovered in 1969 by Pierre Guerin, which starts from the inner edge of the Crepe ring, possibly reaching all the way up to the planet's surface, and an E ring extending from the outer edge of the A ring to a distance as much as 50 times the radius of Saturn. Between the rings C and D is a dark space called Guerin division.

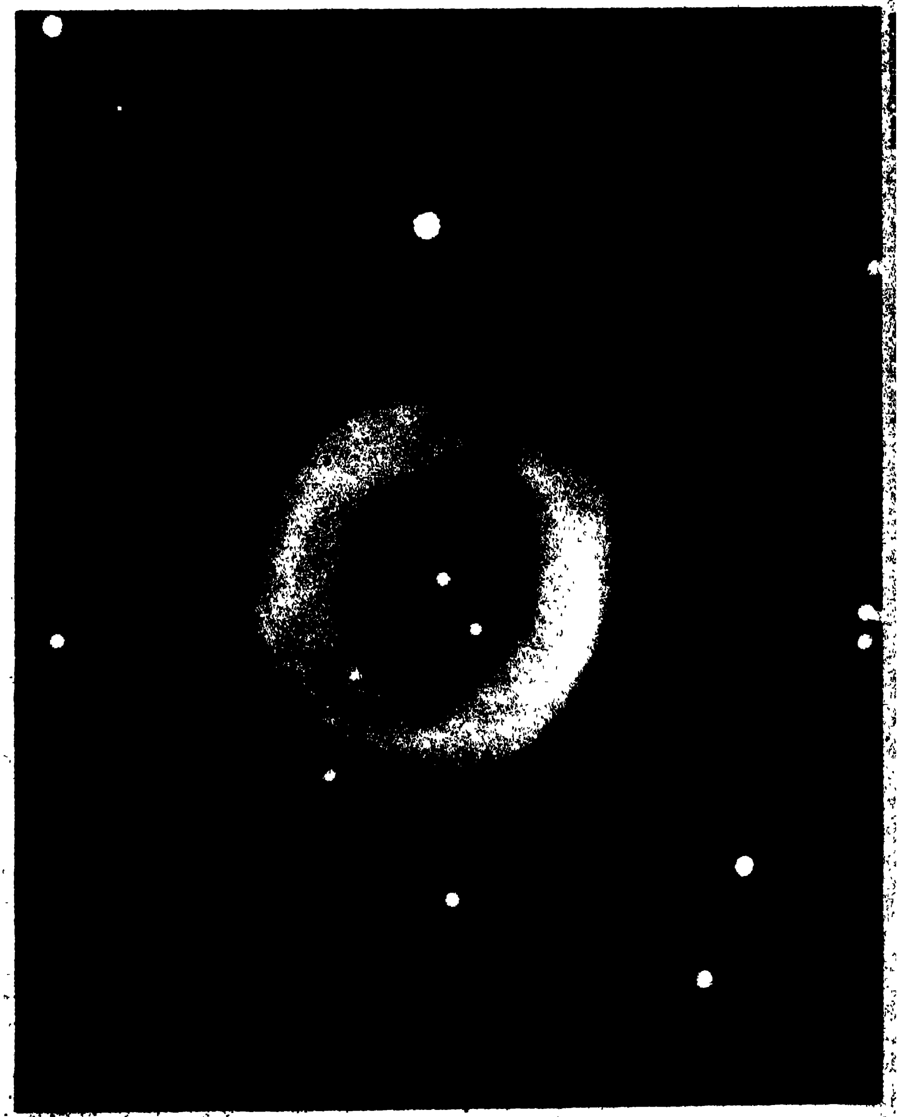
To this plethora of rings and gaps, the Pioneer 11 observations (Sci-

The great Andromeda Galaxy (above) is faintly visible to the unaided eye. Its disc-like structure becomes clear when seen through a telescope

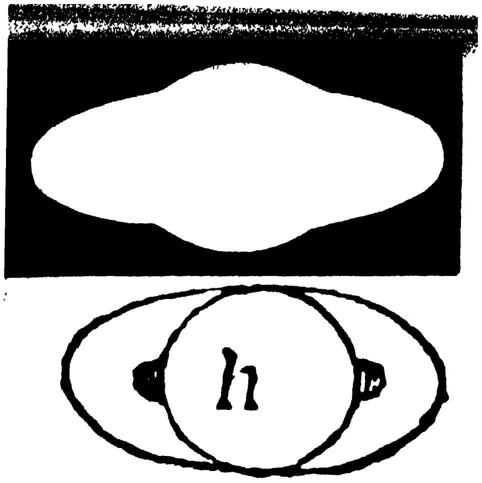
ENCE TODAY, November 1979, p 52) added one more, the newly named F ring. Inevitably, another dark gap separates the F ring from the A ring; informally this gap has been christened "the Pioneer division"

Through telescopes, the bright rings appear as luminous as the planet, but observations show that these are not solid rigid structures. On a few rare occasions when the planet had occulted a bright star, the star was seen to shine through the rings indicating that there are gaps within the rings. Several other observations point to the inescapable conclusion that the rings consist of numerous small bodies rotating around the planet. The amount of sunlight reflected from these regions suggests that the bodies are ice-coated. But there are no definite indications as yet whether these bodies are composed of fine grains of matter or large chunks of rocky material. This is one of the problems planetary scientists are looking into.

The rings lie in the equatorial plane of the planet which is inclined to its



The ring nebula in Lyra, at right, when viewed telescopically appears to be a bright ring but it is actually a thin nebulous glowing shell. This illusion is due to the projection effect; it arises because near the circumference more volume of glowing gas comes along the line of sight and contributes to the brightness; the central regions by contrast appear dark since the thin shell's contribution to brightness in this direction is very small



Galileo's sketch of the rings of the planet Saturn. As he saw through his telescope, he said "It is three-fold". With a crude and low magnifying telescope, to him the planet appeared to have two appendages, one on each side. It must have looked to him very much like the modern overexposed photograph (on top) of Saturn

orbital plane, the orientation being very similar to that of the earth. As a result of this, the appearance of the ring changes with the planet's orbital phase. (SCIENCE TODAY, May 1979, p 52). Twice during the planet's 29.46 year orbital period when the earth moves into their plane, the rings are seen edge-on. They appear as a straight thin line on each side of the planet and gradually become almost invisible. This feature, then known as lobes or ear-like appendages attached to the Saturn, had Galileo worried when he lost the rings for a couple of years after his initial discovery. It was the same feature which became the strong point in Huygens's explanation of Saturn's rings in which he described these as materials forming the annuli and rotating around the planet like its satellites. Huygens's argument was as follows. Since Saturn, its moon and its appendages are parts of the same system, it is possible that they had a common origin and all of them obey the same law of rotation. As the orbital periods of the moon around the Saturn are between several days to a few weeks, the appendages by analogy should rotate in a few hours as they are closer to the planet than the moons are. Since the period after which they become invisible is too long compared to their orbital period, they possess a form which does not change during rotation. This form has to be ring-like.

The origin of the planetary rings

The question about the origin of the rings has intrigued many theoreticians. In the eighteenth century, the Kant-Laplace hypothesis on the formation of the solar system tried to explain the structure on the basis of condensation of a rotating cloud. Though basically sound, the hypothesis needed to explain quantitatively many observed features. An alternative theory was put forward by the French astronomer Albert Roche in the middle of the nineteenth century. He attributed the rings to the tidal disruption of a satellite straying too close to the planet.

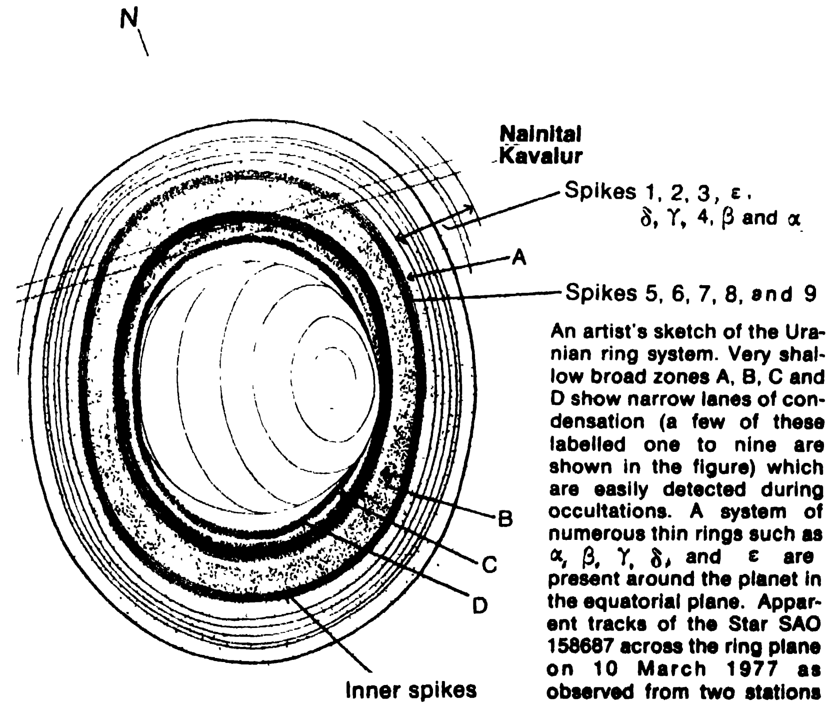
Roche calculated the limiting distance within which foreign bodies break up and the debris eventually get distributed around the planet to form rings. This is called the Roche limit and was found to be 2.44 times the radius of the planet. The rings of Saturn lie within this Roche limit. Several additional assumptions, however, had to be made to explain the breadth and divisions of the rings.

As new observational facts become known, the original postulates require modifications. After the recent discovery of the rings around two other planets, Uranus and Jupiter, the ring feature appears universal rather than unique, and these observations tip the balance more in favour of the condensation hypothesis. We know that Saturn's rings consist of a conglomeration of solid particles coated with a reflecting layer of ice but we do not know whether these are the remnants of the primeval matter which failed to coalesce into a satellite.

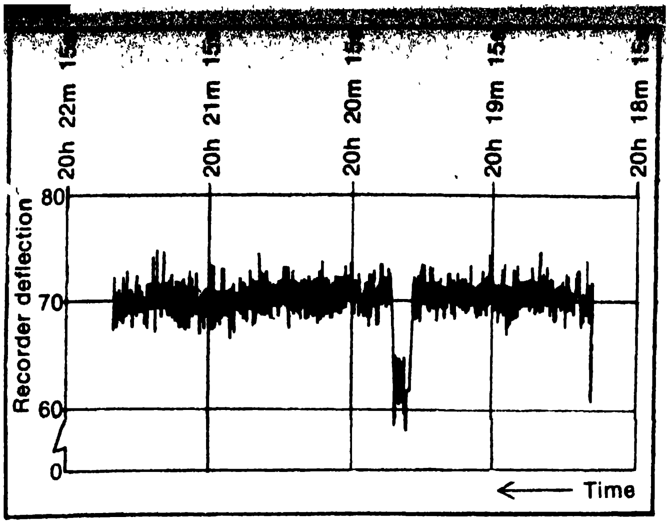
Rings of Uranus

If the discovery of Saturn's rings by Galileo is termed accidental, the recent discovery of the Uranian rings may have to be termed providential because here chance played a truly prominent role. The rings of Saturn would have anyway been discovered when a telescope was eventually pointed towards the planet, but the discovery of the rings of Uranus would not have been possible but for a rare celestial combination.

The date was 10 March 1977. The planet Uranus was expected to occult a ninth magnitude (a term indicating the brightness of an object) star SAO 158687 in the constellation Libra. These are occasions when valuable data about the occulting planet's atmosphere can be collected. As the starlight penetrates the occulting planet's atmosphere, it gets dimmed. It is the rate of dimming that reveals the details of the planet's atmosphere. A few seconds' data can provide information which probably could not have been obtained even after years of observation with a large telescope. On this occasion several groups of scientists were recording the event photoelectrically, when some unexpected dips were noticed by some groups. Among them were one from India at Kavalur and the other two from the USA, one stationed in Australia and another in Kuiper airborne observatory at an altitude of 1330 metres over the south Indian Ocean. All these groups independently surmised that the dips were caused by a hitherto unknown satellite of Uranus. When all the three observations were combined it became apparent that the dips were not due to individual satellites, but to four complete rings of matter surrounding the planet. A careful analysis of the records later brought out a detailed scan of density variations across the Uranian ring system; in fact, these are the finest scans across any ring structure ever



An artist's sketch of the Uranian ring system. Very shallow broad zones A, B, C and D show narrow lanes of condensation (a few of these labelled one to nine are shown in the figure) which are easily detected during occultations. A system of numerous thin rings such as α, β, γ, δ, and ε are present around the planet in the equatorial plane. Apparent tracks of the Star SAO 158687 across the ring plane on 10 March 1977 as observed from two stations in India are also shown



record of the occultation event by Uranus obtained at Kavalur on 10 March 1977. The dip in intensity is due to the ε—ring condensation of the Uranian ring system

recorded. In spite of our familiarity with the rings of Saturn for the past three and a half centuries, we do not have a single scan of comparable quality across this system. This is because precise photoelectric scans were possible only after the middle of the present century. No suitable occultation of a bright star by Saturn has occurred since then.

It is perhaps worthwhile recounting the fortuitous circumstances which helped the discovery. The finest records were obtained from two observations in India at Kavalur and at Nainital which were ideally located for the particular event. Separated by one-and-a-half thousand kilometres, both places enjoyed clear still skies and had in their command the largest telescopes used in the experiment. In its orbital path, the queerly oriented Uranus exposed its unseen ring plane at a convenient angle to offer a long passage of the trail of the occulted star; a similar event ten years earlier would have revealed much less information. Above all, the Indian scientists were even prepared to miss the main occultation event; they had geared themselves for recording the possible small variations that would be caused by the outermost layers of the Uranus's atmosphere. Minute variations in the starlight passing through the thin ring plane which were clearly and unmistakably recorded at both the telescopes showed remarkable similarity.

Many of the features of the Uranian ring system recorded by these two groups were confirmed by several observatories all over the world. When all these data are combined, the Uranian ring system appears quite similar to that of Saturn's. The broad thin rings are concentric with the planet and lie in its equatorial plane. One additional feature that attracted attention was the narrow zones of concentrated matter presumably embedded in the ring plane. It was while investigating this feature that the scientists found the rings.

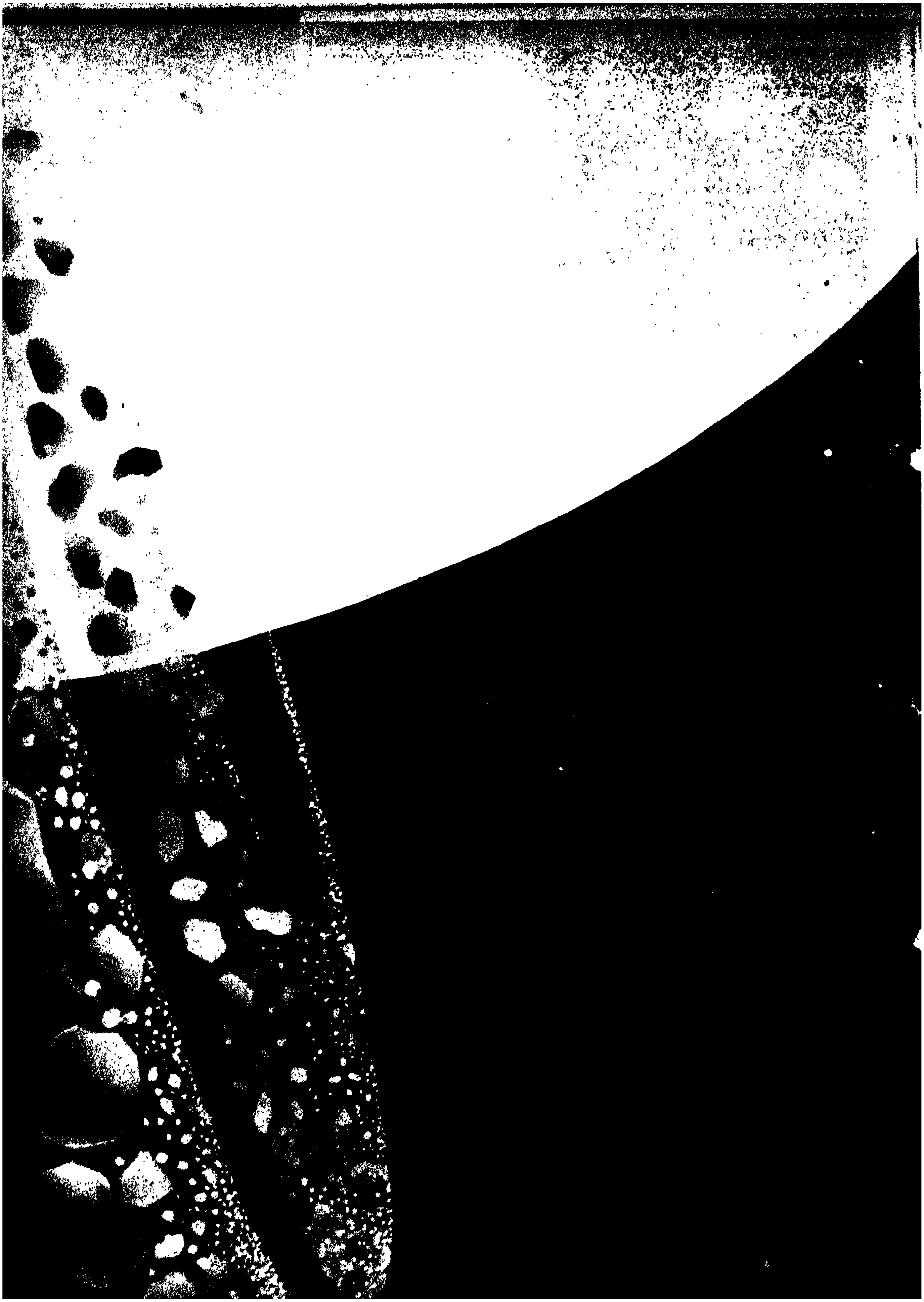
One remarkable contrast in the cases of Saturn and Uranus is that the original crude picture of Saturn became clearer as detailed and refined observations came in. In the case of Uranian rings, the first fortuitous data were so detailed as to have caught the scientists napping. Although the presence of narrow irregularities was theoretically speculated and quite actively sought for in observations of Saturn's rings over decades, the data indicating their presence in the Uranian ring plane created confusion. To tie the observations down to an unusual model of the ring structure, exotic explanations were put forth by many scientific groups.

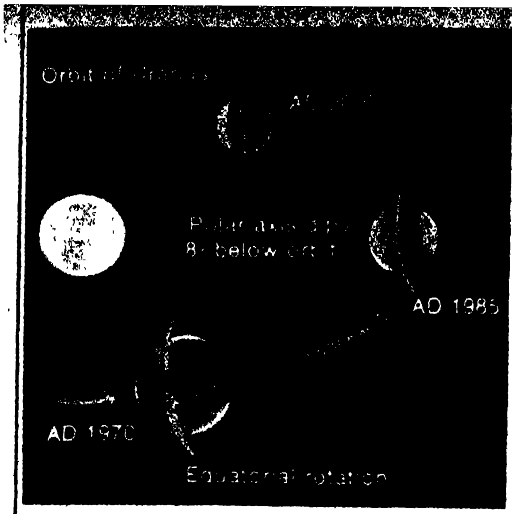
Another point worth noting in this connection is the fact that some natural events provide the scientists with means by which almost impossible observations can be made. The total solar eclipse (SCIENCE TODAY, February 1980) underlines this aspect. In the case of the Uranian rings, specially the rich fine details of the structure, there appears no other means of detecting them except through similar occultations. We may not have another opportunity comparable to that of 10 March 1977 occultation for decades to come, but scientific efforts are intensified and experimental capabilities strained to the limit to detect newer features or verify earlier ones of this elusive ring system. However, after the March 1977 event, there have been a few occultations, of much fainter stars by Uranus in which some of the earlier findings have been confirmed.

Why is it almost impossible to get a picture of the Uranian ring using the existing techniques of photographic registration as in the case of Saturn? The ring materials are too thinly distributed and therefore too dark to reflect enough sunlight by which they can be detected. Besides, the strong glare produced by the planet outshines the rings. Attempts have been made with the 200-inch Hale telescope to photograph the rings by increasing the contrast between the planet and the rings. This was done by using some bands of infrared radiation which the planet selectively absorbs and the rings reflect back but the efforts have been met with limited success. All eyes are now on the spacecraft Voyager 2 which is expected to fly close by Uranus in January 1986 and send back details of the normally invisible ring of matter around this far away planet.

This photograph (on top) of the Jovian ring system taken in early July last year by Voyager 2 spacecraft shows the bright and sharp outer edge, along with the fainter inner continuous sheet of particles between the edges

(At right) The Saturnian ring system was photographed by pioneer spacecraft early September last year. This is the "discovery photograph" showing a new ring called F and a new satellite now named 1979-S 1





The orbital period of Uranus around the sun is 84 years. Like all planets, Uranus spins around its axis but the queerest thing about it is that unlike other planets its spin axis lies in nearly the same plane as its orbit around the sun The equatorial plane of Uranus (and hence the ring structure) is almost perpendicular to the direction of earth at some phases of the planet's orbital motion. Passages of stars, whenever occulted are likely to be near-parallel to the equatorial plane of the planets

Rings of Jupiter

The saga of discovery of Jupiter's rings had a different course altogether. Unlike the Uranian ring system which was discovered almost by accident, the discovery of Jupiter's rings came after several years' efforts by space scientists. On the eve of the fly-by missions to the giant planets, scientists had been taking stock of the existing ideas of the solar system—the uniqueness of the planet Saturn having a ring around somehow appeared inconsistent with the laws of nature. The four outer planets, Jupiter, Saturn, Uranus and Neptune, do not appear very dissimilar as regards their size, compositions and many other physical features and it is, therefore, incomprehensible that only one of them should have a system of rings. The speculation that there might be a system of rings around the planet Jupiter was voiced and discussed when the observation programmes of the Pioneer 10 mission was drawn up. Some observations for detecting the ring, if one existed around Jupiter, were planned for the fly-by period.

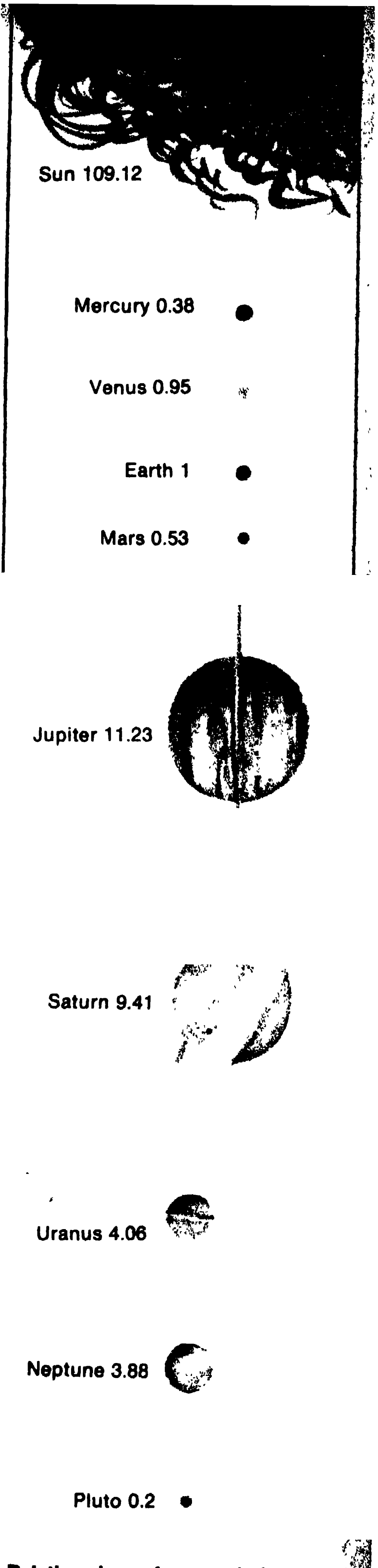
Pioneer 10 in 1973, however, drew a blank; so did the following mission Pioneer 11 in 1974. Both failed to catch any signs of a ring system around Jupiter. But with the discovery of the Uranian rings arguments in favour of a Jovian ring had become very strong. It was argued that the elusive Jovian ring must be very faint; and thus special techniques were adopted for its detection. On 4 March 1979, the spacecraft Voyager 1, during its passage across the equatorial plane of the planet, obtained the first photograph of the Jovian ring. A photograph obtained through an 11-minute long exposure from the slightly rocking space platform showed the ring as a series of bright streaks. The existence of the rings was proved and it was also found that they were very thin and circled the planet along its equatorial plane.

The next step was to obtain more information about this system. Voyager2 was to study it in detail. Since the ring lies in the equatorial plane, it would be necessary to photograph the feature from a position away from it. The fly-by trajectory showed that 26 hours after the closest approach to the planet on 9 July 1979, the spacecraft was to pass through a spot in the shadow cone cast by Jupiter from which a slant view of the rings would be possible. This was considered an ideal moment because, besides being in the shadow cone, the spacecraft would be about 2° away from the equatorial plane. In that location, the high phase angle would enhance the brightness of the ring considerably, making the task of image recording easier. The manoeuvre was carried through successfully resulting in some strikingly beautiful pictures of the Jovian rings (SCIENCE TODAY, October 1979, p 42).

The Jovian ring system, as far as the present knowledge goes, is again similar to the Saturnian one. It has at least four distinct components in the form of thin annular discs, all lying in the equatorial plane of the planet.

The outermost ring is comparatively faint and has been traced up to a distance of 200,000 km from the planet. It encircles a narrow bright ring of about 800 km width. Still nearer the planet is the third com-

At left, an artist's conception of the rings of Saturn



Relative sizes of sun and planets

The relative sizes of the sun and planets and the order in which the planets orbit the sun are shown in the figure at right. The ecliptic is the sun's path among the stars and is identified with earth's orbit round the sun. The orbital planes of all planets except that of Pluto, lie very close to the ecliptic. Three of the massive planets, Jupiter, Saturn and Uranus, have ring systems around them. These ring systems lie in the equatorial planes of the planets. The inclination of equator to the orbit in 3°4'; 26°44'; 97°53' in the case of Jupiter, Saturn and Uranus, respectively

The changing scenario of the planetary rings

EVER since Uranus and Jupiter were found to be ring-encircled planets, planetary scientists have racked their brains to find an answer to the question, 'Why do only some planets have rings?' For that we must first find out how the rings form. It is believed that the Saturnian ring system, which is primarily made up of ice, was formed during the condensation of the proto-planetary nebula.

According to some scientists, the dark rings of Uranus were perhaps formed about 10 to 100 million years ago due to the break-up of carbonaceous bodies (satellites or meteoroids) which were non-spherical and mechanically weak. An almost similar body is said to have smashed to smithereens and produced the Jovian ring about a million years ago. There are also speculations that Jupiter's powerful gravity could have trapped interplanetary material, impact debris from its moons, Amalthea and Io, and even ejecta material from the so-called volcanoes of Io to form a ring system around itself.

Even if Neptune does not have a ring at present (whether it has, will be checked by the Voyager 2 mission on 1 September 1989), it will probably have a ring a few million years hence. It is believed that one of its satellites, Triton, which is probably the largest moon in the solar system, has a retrograde orbit. This makes the orbit of Triton highly unstable and it is therefore slowly spiralling into Neptune. As it comes well inside the Roche limit, it may break up into bits, which in turn will collide with each other to produce a myriad of smaller grains; these grains could orbit the planet in the form of rings.

Another planet vying with Neptune to obtain a ring around it is Mars. It will be interesting to wager (if one could live that long) which of the two planets will acquire it first. Phobos, one of the potato-shaped satellites of Mars, is within the Roche limit of the planet and is being pulled towards tho planet; within the next 100 million years or so, it will either crash on to the planet or be torn apart, and its dark carbonaceous material will form a ring around Mars.

Rings may be a temporary phenomenon. According to some scientists, Saturn's ring particles are being whittled away. It is estimated that the erosion of the particles is taking place on time-scales of hundreds of millions of years. Compared to the age of the solar system (about 4.5 billion years), this time-scale is too short and perhaps the ring particles are nearing their end.

Observations of erosion rates have indicated that most of the particles that are at present about a few centimetres in diameter were a few metres in diameter at the time when the rings were formed; that is, at the time of formation of the planet Saturn itself. What were the mechanisms responsible for abrading the large snowballs formed at the moments of the origin of the planetary system? A process that one immediately thinks of is the evaporation of icy particles by sun's heat. But Saturn is so far away from the sun that the temperature of the ring particles is only about 90°K. Thus the thermal evaporation of particles even in vacuum-like conditions existing in outer planetary space is improbable.

The other process responsible for the slow mechanical erosion of particles is known as sputtering. The rings are constantly bombarded by micrometeoroids and solar wind particles such as electrons and protons, knocking out tiny chips of ring particles in billiard ball-like fashion. Ultraviolet rays from the sun also do their bit by knocking off a molecule or two from the surface of a particle. Even ordinary sunlight falling on the tiny rocky grains makes them spiral down into the planet, the so-called Poynting-Robertson effect. Slowly but surely, Saturn is losing its rings.

None of the particles in the Jovian ring remains there long. The ring seems to be only a sojourn for particles on their way to the planet. It is thought that bombardment by the intense flux of protons trapped in Jovian Van Allen belts also erodes particles. Calculations show that small grains are being eliminated on the time-scale of a million years and the Jovian rings are expected to have about the same life time.

Perhaps the slow-spinning planets, Venus and Mercury, also had moons once and these were dragged inside because of the slow spin periods of the planets. The moons might have broken up and formed temporary rings around the planets.

Having captured a large stray body like the moon, our earth seems to be an anomalous case. But will anything happen to this moon? The earth exerts a strong gravitational pull on the moon making the near-side of the moon denser than the other half.

The orbit of the moon is not stable. The satellite is receding away from the earth. But after billions of years, the gravity of the sun and the earth together will force the moon to come closer to the earth. Then the internal gravity of the moon, which holds it together, will not be able to hold out against the pull of the earth. The tug of war between the two will result in the two faces of the moon trying to go their own way. In the process, the moon will break apart and form a Saturn-like ring system around the earth.

JYOTI NEVATIA

ponent, a fainter ring which is 6000 km wide. From the inner edge of this faint ring to almost the visible surface of the planet stretches the fourth ring—a thin, nebulous structure, very faintly discernible in the Voyager's picture.

After considering several observed factors, Voyager 2 scientists favour a hypothesis for the origin and maintenance of the rings which depicts these as steady state configurations of small particles moving in orbits in the equatorial plane. Particles, according to them, keep falling on the planet through the inner ring and are replenished from sources outside the Roche limit. These could include cometary and meteoric debris, impact ejecta from inner satellites and volcanic ejecta from the Galilean satellite Io.

The density of the Jovian ring particles will thus be controlled by the relative periods of stable orbiting objects in the zone and is influenced by the gravitational attraction of the planet and its satellites. Regions where the perturbations are large will rapidly dispel the infringing particles to relatively more stable orbits. Similar theories were invoked earlier in trying to explain the divisions of Saturn's rings. Locations of divisions were seen to be correlated to the resonance effect of orbital periods of Saturn's satellites as required by the theory. Only the source of the ring particles were undecided.

Is there fing around Neptune?

Since three of the four giant planets in the solar system are known to possess a ring system, the speculation that Neptune too has rings has favourable odds. Only the detection appears to pose a problem of formidable proportions. Neptune is very far; it is at a distance which is four times that of Saturn from the sun, and double that of Uranus. If it has a faint ring system similar to that of Uranus and Jupiter, it will be quite difficult to detect it against the sky background. Even the occultation method does not appear very favourable; because, unlike Uranus, the equatorial plane of Neptune is not much inclined to the ecliptic and thus a similar ring, if present, will cover only a narrow segment of the sky as seen from the earth. The chances of occultation of a reasonably bright star passing through this segment are very, very remote. But in spite of this, all possible chances are being investigated. In several observatories of the world, new faint star charts are being intensely studied for possible occultation or appulses by the outer planets. Appulses are not exactly occultations, but close passages. The 10 March 1977 event as seen from India was really an appulse.

(Continued on p. 34)

The nucleon-nucleon interaction from the quark viewpoint

UNDERLYING the rich variety of nuclear phenomena is the basic interaction between two nucleons. The following properties of this interaction have been unravelled, mostly from neutron-proton and proton-proton scattering experiments at low energies.

Firstly, there is a repulsion between nucleons at short distances of the order of 0.5×10^{-13} cm. Secondly, the central part of the interaction, that is, the part which depends only on the magnitude of the vector distance between the two nucleons, is a sum of the space, spin and isospin exchange parts. Thirdly, there is the spin-orbit potential describing the coupling between the total spin and their relative orbital angular momentum, acting between nucleons. And lastly, the presence of the so-called tensor force (a spin-dependent force having the same form as the interaction between magnetic dipoles) is also essential in accounting for the cigar-like shape of the simplest nucleus, the deuteron. Any successful theory of the nucleon-nucleon interaction must obviously explain the origin of all these distinct features.

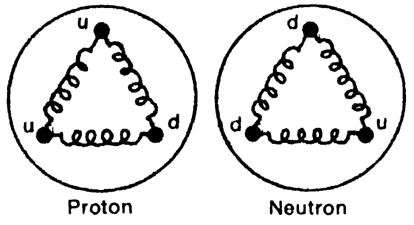


Fig 1 Schematic representation of the quark-constitution of nucleons Quarks inside hadrons are held together by massless gluons (depicted as coils here) which mediate the qq colour interaction

As a prelude to an understanding of the nucleon-nucleon interaction, let us recapitulate the two ways in which physicists describe the interactions between particles. The classical theory often describes the forces between particles in terms of concepts such as the *potential* and the *charge*. Notwithstanding the inherent classical nature of these concepts, they may be retained in a quantum theory as well. The coulomb potential between static electric charges is a familiar example. The potential model is both intuitively appealing and sufficient for low-energy interactions. At higher energies the description is quite different—it is in terms of quantum fields. This latter description is the more microscopic and more general of the two. There is also a relation between these two descriptions; the potential between interacting particles can be abstracted from the quantum field theory which describes the same interaction in the non-relativistic limit and from the quantum field point of view the interaction arises through the propagation, that is, exchange, of the so-called intermediate bosons between the particles in question. The photon is the intermediate boson which mediates the electromagnetic interaction, for example between an electron and the nucleus of an atom.

About four decades ago, in the pioneering work of H. Yukawa, the first successful ideas on the nucleon-nucleon interaction appeared which fetched for him the 1949 Nobel prize. According to him, this interaction is mediated by intermediate bosons, especially the pi meson (pion). A major criticism against Yukawa's theory is that it completely ignores the recently well-established quark constitution of hadrons. However, we must appreciate that this drawback could not have been overcome by Yukawa himself, for, in the days when his theory appeared, nucleons and mesons were conceived only as structureless point particles. Indeed, any satisfactory theory of nuclear forces must recognise the participation of quarks to be more fundamental than that of mesons

An attractive theory of the nucleon-nucleon interaction which regards quarks and gluons as the basic entities in hadronic interactions has been proposed in recent years. There are many minor variations in such theories, but all of them attribute the nuclear force to the strong interaction between quarks and gluons that arises from the colour degree of freedom. The seminal ideas of such theories for nuclear phenomena came mainly from D Robson. From the quark viewpoint the nucleons have structure The proton is built up of three quarks, each carrying a different amount of "colour-charge" (see SCIENCE TODAY, October 1979, January 1980 and March 1980). But two of these are of the *up* type, whereas the third is of the *down* type. Likewise, the neutron is built of three quarks, each carrying a different amount of colour-charge. But now two of these are of the *down* type, whereas the third is of the *up* type.

The colour-charge which quarks carry is what generates the strong forces which operate between the quarks as well as between and within the hadrons (Fig. 1). Notice that even though hadrons are constituted by quarks which carry the colour-charge, their own net colour-charge is zero. This circumstance, in which one is calculating the colour-force between colourless nucleons, is reminiscent of the Van der Waals force between atoms. In the latter case, one calculates the electrical force between electrically neutral atoms, say between two helium atoms (Fig. 2). We can anticipate from this analogy that the attractive force between nucleons calculated in this way will turn out to be rather weak, which is in fact what our calculation shows.

We start with the one-gluon exchange potential model for the quark-quark interaction. Such an exchange, which takes place between two quarks of specified colours, will result in the quarks changing their colour-charge This is a unique feature of the colour-dynamics of quarks and is absent in the familiar electromagnetic case, where the exchange of a photon does not change the electric charges of the interacting particles. Since these gluons happen to be massless, the quarks primarily interact through a potential which is inversely proportional to their spatial separation. This then is the leading behaviour of the quark-quark potential only at short distances At large distances, quarks tend to be pulled inward by the confining mechanism, which we represent in our model by a potential which is proportional to the square of the quark-quark separation. Finer corrections to these leading terms are the quark-quark spin-orbit and tensor potentials. This potential model of quark-quark interaction which we use is consistent with quark confinement and it is further justified by the fact that it can be abstracted from the theory of quantum chromodynamics (in the non-relativistic limit) in just the same

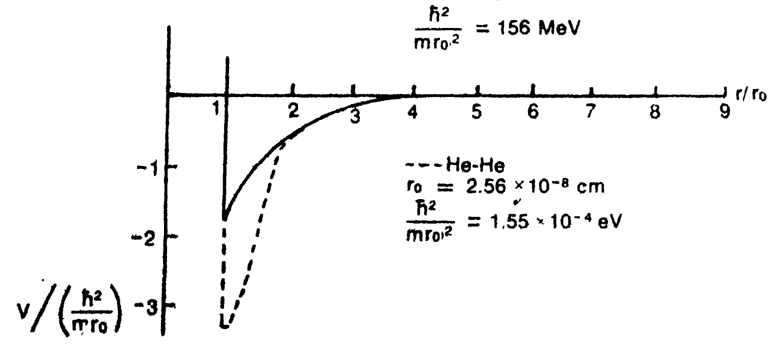
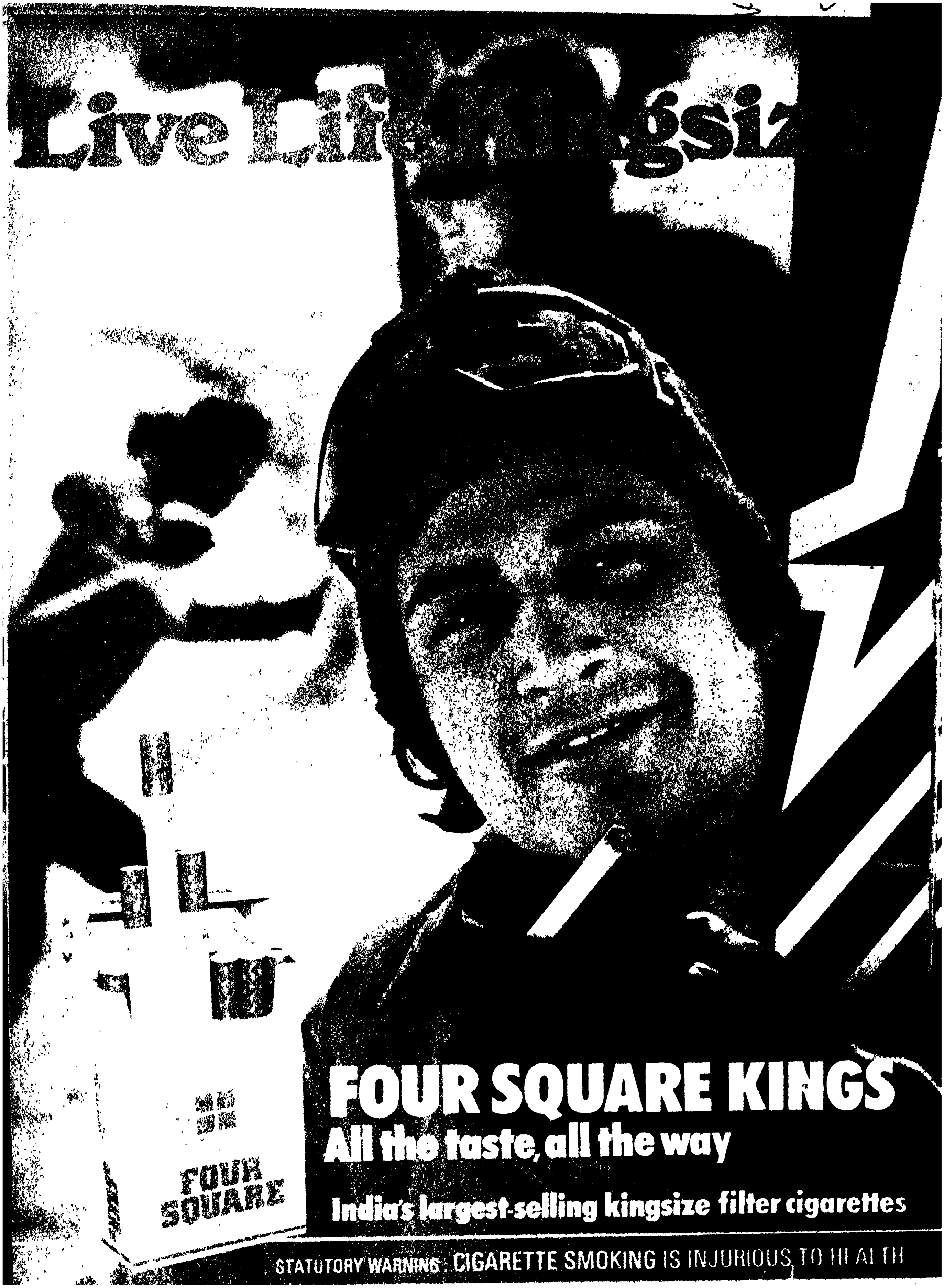


Fig. 2 Analogy between the phenomenological potentials between nucleons and helium (He) atoms, emphasising the weak attraction in both cases V is the potential and r is the inter-particle distance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way as the meson exchange potential was obtained by Yukawa from meson field theory.

Imagine now two clusters of three quarks each. By virtue of the quark-quark interaction defined above, the two clusters will exert a force on each other, which we interpret as the nucleon-nucleon strong force. The nucleon-nucleon potential is essentially the average value of the six-quark energy in the two-cluster six-quark completely antisymmetric state. However, it turns out that the 'direct part' of this force vanishes, whereas it is only the 'exchange-part' which is non-vanishing. The immediate implication is that the nucleon-nucleon force arises only when constituent quarks are exchanged between nucleons.

What features of the nucleon-nucleon force are accounted for by this quark-exchange mechanism? The short-range repulsion is the main result of this calculation (*Physics Letters* **89B** 17). Further, the nucleon-nucleon potential also turns out to be the sum of the space, spin and isospin exchange parts. The other observed features, such as the intermediate-range attraction and the spin-orbit and tensor parts, all happen to be too weak in the present model even though they turn out to have the correct signatures. Therefore, all that one can say is that the colour-force between quarks and their exchange between nucleons are responsible only for the repulsive interaction at short distances.

The present method of calculating the potential between nucleons is by no means unique; this is just one of the possible calculable models. Starting with the MIT bag model of hadrons, C. De Tar, after independently calculating the nucleon-nucleon interaction, finds once again the short-distance repulsion. The main merit of De Tar's calculation lies in the MIT bag model being a relativistic one but, apart from this advantage, De Tar's calculation faces a number of other ambiguities. Further efforts in this field will probably be directed towards the resurrection of the one-meson exchange potential from this modern quark viewpoint.

R. SHANKER

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Anomalous redshifts of quasars

THE FIRST two quasars 3C 273 and 3C 48 (catalogue numbers on the third Cambridge compilation of radio sources) were discovered in 1963 during the radio survey of the skies. The astronomers found that some of the radio sources were associated with star-like optical objects. Since ordinary stars do not emit detectable amount of radio waves, these star-like objects were something special and were called quasi-stellar objects or quasars. The remarkable property of these early quasars which excited the astronomers most was the large redshifts in the light they emit. The redshift of 3C 273 is 0.158 and of 3C 48 is 0.367.

The redshift indicates the fractional increase in the wavelength of spectral lines. Thus if, from laboratory data, the wavelength of, say, the Lyman - line of hydrogen is 1216 Angstrom, a redshift of 2 will take the wavelength to three times this value to 3648 Angstrom. For most galaxies the redshift is less than 0.2 although a few show redshifts greater than 0.2 and may go up to around 0.9. The optimism that the early quasars generated, that quasars by and large will turn out to be high redshift objects, has been justified. There are now over 1300 quasars identified and their redshifts range up to 3.53

However, the hope that quasars will provide definite probes of the remote past epochs of the universe has not been justified For, this depends on the confirmation that redshifts of quasars do arise from the expansion of the universe. If this can be confirmed, cosmologists can argue that quasars obey the Hubble's law which states that the redshift of a quasar increases in a fixed proportion to its distance If a quasar with redshift 2 obeys Hubble's law, then it is nearly ten times as far away from us as a galaxy of redshift 0.2, and about a hundred times further away than galaxy of redshift 0.02.

But the evidence that quasars obey Hubble's law has been slow in coming and, according to some, it has not come at all! Six months ago Geoffrey Burbidge reviewed the data on quasar redshifts (*Nature* **282** 481) and pointed out the growing number of cases of the so-called 'anomalous redshifts', which cast doubt on whether quasar redshifts also arise from the expansion of the universe, as the redshifts of galaxies do

Since the early 1970s evidence has been coming, largely from the observations of H. Arp of the Hale Observatories, that high redshift quasars exist close to low redshift galaxies. Since the astronomer cannot directly assert that two objects seen close to each other in the sky are physically near each other, many observers have tended to dismiss Arp's data as merely accidental coincidences of directions. Thus, if Arp pointed to a quasar of redshift 2 near a galaxy of redshift 0 02, the doubters would argue that this observation simply indicated that the direction to the quasar accidentally fell close to the direction of the galaxy.

However, statistics of such close associations have grown to around 120 cases and it is no longer possible to dismiss them all as accidents. Even so, A. Stockton had shown, in 1978, 13 cases of low redshift quasars lying close to low (and nearly equal) redshift galaxies to prove that at least the low redshift quasars were at cosmological distances.

The traditionalists are considerably cheered by Stockton's results and feel that these demonstrate conclusively that quasar redshifts are cosmological. However, even Stockton found 12 other cases where quasars and galaxies of different redshifts were close to each other, the degree of closeness of these 12 being no different from the degree of closeness of the first 13 pairs. Why then does Stockton completely ignore the latter pairs?

Recently, Arp and his colleagues have found another series of anomalous redshift cases which are even more difficult to dismiss as chance coincidences than his earlier cases. In some cases two quasars of equal (and high) redshifts are found on opposite sides of a galaxy of low redshift. In fact, in a few remarkable cases, three or four such quasar pairs are aligned across a galaxy. In the most remarkable configuration of all, Arp and C. Hazard have found two quasar triplets. Each triplet has three quasars in a line. Again, there is redshift bunching: that is, for each quasar of one triplet there is a quasar of nearly the same redshift on the other triplet. Are these all chance cases?

In a paper to appear in the *Astrophysical Journal*, 1 September 1980, P.K. Das and I have taken the view that the anomalous redshift cases are no longer dismissible as chance coincidences and that the high redshift of a quasar does have a non-cosmological component. There are, however, good reasons to rule out the Doppler effect (shift of the spectral lines of an object towards the red end of the spectrum due to the high recessional velocity of the object) or the gravitational redshift (reddening of light of an object due to the presence of an intense gravitational field) as being likely sources of this non-cosmological component. Instead, we have suggested that a fourth type of redshift arising from the variable particle masses in the Hoyle-Narlikar cosmology may have to be invoked to account for the alignments and redshift bunching. If the anomalous redshift data are considered non-trivial, then some such drastic solution to the quasar redshift problem seems unavoidable

J. V NARLIKAR

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Archaeological dating by electron spin resonance

ONE can date an archaeological sample by carbon-14 dating up to 50,000 years Yet another method is to estimate the amount of radiation the archaeological specimen has been subject to, over its entire history, from the radioactivity of the surroundings. In solids, radiation exposure causes what is commonly described as radiation damage, which is manifested as defects in the lattice, and the concentration of these defects up to a certain limit is proportional to the integrated dose of radiation. Beyond the limit, the concentration of lattice defects exhibits saturation. The estimation of the concentration of defects yields readily the age of the fossil if the dose rate due to natural radiation is known for the site. Since estimates of natural radiation are available for different sites, any method, which in principle determines the concentration of lattice defects, can be used for dating an archaeological sample

One of the well-known methods to determine the concentration of radiation induced defects of a particular type, such as the trapped electrons and holes is thermoluminescence. Thermoluminescence methods have been employed for dating potteries and ceramics.

Yet another method to measure radiation defects which are paramagnetic, such as trapped electrons, holes and free radicals, is the electron spin resonance (ESR). ESR is a spectroscopic measurement of the transitions (mostly in the microwave frequency region) between the electron spin energy levels of a paramagnetic species in a magnetic field (of about 3500 gauss). An electron has what is known as a spin (which can be visualised crudely as a precession) and associated with the spin is its magnetic property. Such a property is also shared by many other particles like the protons and the neutrons. In a magnetic field free electrons can take two possible energy states depending on whether they are aligned parallel or antiparallel to the magnetic field. It is similar to a bar magnet where the potential energy of the system in a magnetic field depends on the angle the magnet makes with respect to the magnetic field. Since these two electron spin levels have two different energies, with the energy difference dependent on the strength of the magnetic field, resonance spectroscopy can be conducted by applying an electromagnetic radiation of frequency ν such that $h\nu$ energy separation between the spin levels, where h is the well-known Planck's constant. This, in essence, is ESR spectroscopy.

However, one cannot observe ESR in most substances because the formation of any chemical bond involves the pairing of two electrons with opposite spin states annulling the magnetic moment. ESR spectroscopy thus identifies and measures the species where electrons are not paired off due to chemical bonding (so called paramagnetic species), such as many transition metal complexes (inorganic compounds containing Cu^{2+}, Mn^{2+}, Ni^{2+}, Co^{2+}, rare earths,etc), organic free radicals (usually occurring as intermediates in chemical reactions), certain small paramagnetic molecules (O_2, NO_2, NO, etc) paramagnetic defects in the solid state caused by radiation (trapped holes, electrons, free radicals, electron deficient or rich atoms and molecules, such as O and O_2).

The technique of ESR has been recently applied to archaeological dating (M. Ikeya and T. Miki, *Science* **207** 977) by measuring the concentration of radiation induced defects in animal and human bones from different excavation sites whose ages are known archaeologically or historically and are in the ranges of 10^2 to 10^6 years. One advantage of the ESR method is its non-destructive nature but most samples have electron spin spectra from all the paramagnetic species in the samples, many of which are not the result of radiation damage.

In the case of bones, a narrow signal presumably due to O^- created by irradiation of the bones, was utilised for dating and it was clearly established that further artificial radiation of the bone led to a linear increase in this signal with total dose rate. Just as in the case of thermoluminescence what is determined by ESR is the concentration of centres caused by radiation damage and in both these cases the reliability of the age depends crucially on a knowledge of the rate of radiation the sample has been receiving over the centuries from natural radioactive sources at and near the site.

B VENKATARAMAN

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Celelestial rings...

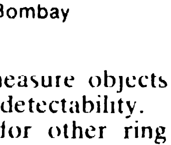
(Continued from p 30)

Ring around the sun?

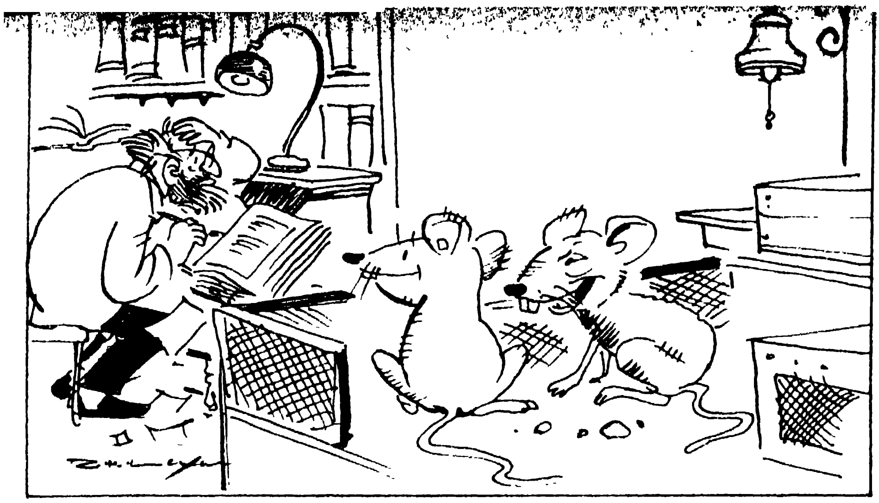
So far, the continued course of discovery of ring-like structures around planets seem to point to the universality of such formations around massive objects. But expectation of a ring structure around massive objects is only an extension of observations. Nobody knows for sure. Extending the idea, one naturally comes across the question whether the sun itself, the major object in the solar system, possesses a ring of materials around it. It is true that the planetary system is only a variant of the familiar ring structure we are discussing. The ring structure basically consists of orbiting satellite matter around planets. In the planetary system round the sun, considerable interplanetary matter, thousands of minor planets (asteroids) and the major planets all move close to the equatorial plane of the sun. Basically this represents a ring-like structure. The only difference being the relative sizes of the ring and the planets. The diameter of the planetary rings are a few times the planets' diameter, whereas the diameter of the solar system is a few thousand times the solar diameter. But is there a possibility of a ring of rocky material circling the sun separated by a few solar radii? The question has recently been discussed by a team of scientists (SCIENCE TODAY, February 1980, p 15) and after considering many constraints from the evolutionary, physical and chemical angles, they conclude that such a formation is possible. They have also considered the feasibility of observing the structure. Under normal conditions detection is out of question; since visually they estimate the brightness of individual bodies in the ring to be between magnitudes 8 and 10 which means it would be fainter than the planet Neptune. Also, it would lie within a couple of degrees of the sun. But during a total eclipse, it is marginally possible to detect these; the task would be easier if one chooses to scan with infrared radiation.

In the recently concluded series of experiments during the total solar eclipse, a group of Indian scientists had devised an experiment to verify this speculation. Preliminary information indicates that no ring particles could be detected; but it is premature to state that the result disproves the speculation. Experimental data need critical examination to be definite, particularly when new devices are being employed to measure objects on the borderlines of detectability.

Besides searching for other ring structures around planets, the present trend of planetary research greatly emphasises the detailed study of the ring features. Fine details of the rings could hold the key to some hitherto unknown physical aspects of the planet. Take, for example, the mass distribution in the planetary interiors which influences them considerably. The nature of ring particles may reveal some vital information in our understanding of the origin of solar system. The whole mechanism of the formation of ring-like structures has so much relevance to current problems in astrophysics that any additional information gained through the study of planetary rings is worth more than the time, money and effort spent on the investigation.



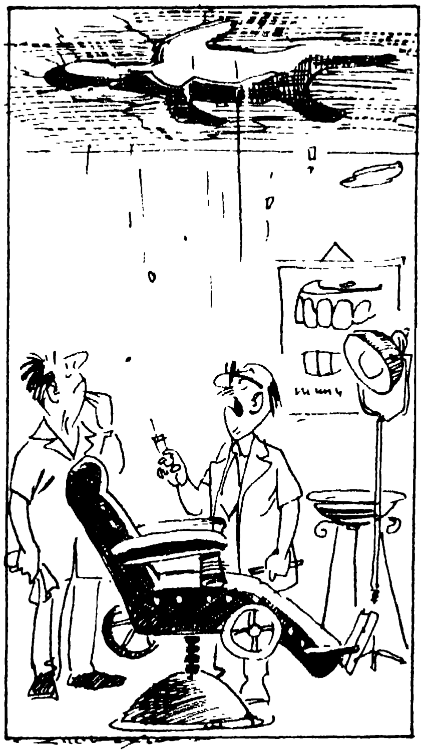
Professor Bhattacharyya is with the Indian Institute of Astrophysics, Bangalore. His specialisation is the field of experimental astrophysics. Among his notable achievements are the discoveries of a thin atmosphere of Jupiter's satellite, Ganymede, and the extended ring structure around Uranus.



"I ruined his work of a life-time! Instead of rushing toward the food when he rang the bell, I deliberately ran in the opposite direction."

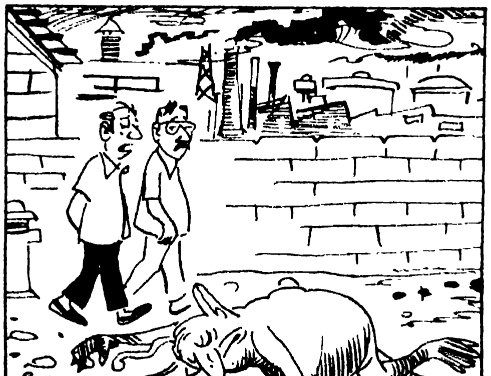
This World of Science!

by R. K. Laxman



'Don't tell me you forgot to administer the pain-killer!"

"Wipe out that I-told-you-so look."



"First it was plants. Then birds. And now it is the poor creatures from outer space."

... and of Scientists

Einstein and Heisenberg

HIS greatness and devotion to science notwithstanding, Einstein seems to have been prejudiced against the quantum theory. Heisenberg recalls his failure to convince him in this regard, when Einstein repeatedly said: "Well, I agree that any experiment, the results of which can be calculated by means of quantum mechanics, will come out as you say, but still such a scheme cannot be a final description of Nature."

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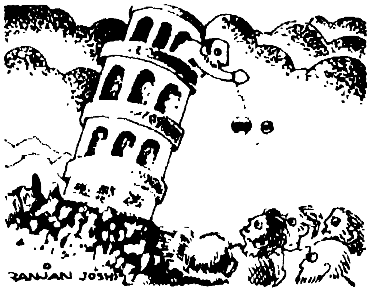


THE problem of falling objects used to attract many scientists. But it was only Galileo who has given some interesting details of what happens after different kinds of objects fall. He wrote (1610) that "although a ball made up of a pound's weight of gold would fall at speed and land with a thud, killing anyone who happened to be standing down below, if this same pound of gold were beaten out into very thin leaves, as it is when it is to be used for gilding, instead of falling like a stone, this same weight of metal would flutter delicately down like so many feathers."

***

ADDRESSING ambitious and aspiring young scientists, the Hungarian chemist and Nobel prize winner for physiology (1937), Albert Szent-Gyorgyi said in sheer anguish: "If my student comes to me and says that he wants to be useful to mankind and go into research to alleviate human suffering, I would advise him to go into charity instead. Research wants real egotists who seek their own pleasure and satisfaction, but find it in solving the puzzles of nature"

S. N. MUNSHI

Uttarpara

How to take science to the masses?

Vivek Monteiro

THE Science Education Group (SEG) was formed in 1976 with the broad aim of propagating a comprehensive scientific attitude among all sections of the people. Why do we say 'comprehensive'? A person who looks at all questions scientifically (and what else does 'scientific attitude' mean?) will, of course, recognise that no real object, phenomenon or process can be understood in isolation from its mutual interaction with other objects and processes. Even so, perhaps the majority of scientific professionals (researchers, doctors, engineers, etc) seldom care to look out of the narrow confines of their area of specialisation. Within their laboratories, they may do excellent and important research, leading to big advances in science. But when they step out of their laboratories they seem to leave their scientific attitudes with their lab coats and gloves.

Thus we have cases like that of the director of a famous institute, who speaks eloquently on conservation laws, including the conservation of mass, and yet proclaims belief in a man who claims to produce watches out of nothing. Or another like that of an astronomer who fasts during a solar eclipse. Such contradictions are, of course, only the more conspicuous examples of the rather unfortunate fact that, in the words of J.W.N. Sullivan, "In their private lives, scientific men are for the most part as prejudiced and slovenly in their thinking as are other men".

The paradox of unscientific 'scientific men' is not difficult to understand. It is not only our education system that encourages compartmentalisation. The social division of labour of modern industry has in the 20th century extended to the sciences, including the basic sciences. A scientist today is expected to fulfil his partial role by producing so many papers a year in a given subject, and is suitably rewarded for doing so. He is not expected to have a world view, a consistent viewpoint extending to all of reality. What results is a fragmented and compartmentalised mind in which contradictions and confusions abound.

That is why it is necessary to emphasise the comprehensive character of the scientific attitude. We would also emphasise the need to propagate science in all sections of the people. For when even scientists are not immune to superstition, irrationality and pseudoscience, the public at large, with less exposure to science, is unlikely to acquire a scientific conciousness on its own. True, today it is impossible for anyone to escape the reach of modern industry, which is based on modern science and technology, the tools, clothing, food, transportation of even a backward villager or an illiterate city *mazdoor* very likely originate in a multi-crore industrial complex. But despite being surrounded by the products of science, the various sections of the public do not acquire a scientific consciousness automatically.

At the inception of the Science Education Group, we decided to concentrate our efforts in the Bombay slums. Why? At that time we felt that the slums were being ignored as far as educational efforts were concerned. Existing science popularisation organisations were for the most part addressing themselves to the literate and educated middle class. Further, having spent many years in the formal education system, we had little faith in its ability to spread scientific thinking. We decided to start independently.

In retrospect, this approach was not very scientific. We did not try to find out what educational work was already going on in the slums, or for the slum population. Nor did we try to co-ordinate with the committed few in the schools and colleges who were trying to effect reforms in science education.

We began our work in the slum with a few individuals teaching science and mathematics for youth in the ninth and tenth standards. The 10+2+3 system had just been introduced. There had been changes in the school curricula, and all the students, without exception, had failed in their examinations. Ours was an uphill task. But since the next examination was six months away, there was not much pressure on the students. Attendance was most irregular. On many occasions, we would arrive at the specified time to find nobody around. It would take another hour to gather the students from their houses, their carrom-boards, and card games.

Soon we discovered that it didn't make much difference whether the student was in the ninth or the tenth standard—or the eighth or the seventh, for that matter. As far as mathematics was concerned, their level was approximately that of a primary school student. How to teach fractional indices to someone who doesn't know what a fraction represents? Some of the members of the SEG, frustrated with this experience, stopped taking classes. What is the use of travelling an hour by bus each way during the evening rush hour if the students weren't interested in attending classes, they asked.

In fact, it is unlikely that our tuition classes in anyway helped the students to pass their examinations. All the tenth standard students failed in mathematics despite our efforts and despite the fact that attendance was very good during the last two weeks prior to the examinations.

Topical questions

Not all our efforts ended in such dismal failure, though. Besides the tuition classes, we had also organised a few demonstrations. The most successful was the telescope demonstration. We set up a 5-cm telescope in an open space. People stood in a long line to look at the moon, children and old folk included. And everybody marvelled at the craters, and there was a heated discussion. A couple of weeks later we had a demonstration of the earth-moon-sun system using a candle, a big rubber ball and a table tennis ball. This too was closely discussed by the youth. Passers-by would stand and watch for a few minutes. But nobody went home to call his family members to come and take a look, as they did with the telescope. We also arranged a science film at the Nehru Planetarium nearby. A board saying, "Chalo Nehru Planetarium", was put up. Two hundred people, young and old alike turned up and we went there in a morcha.

Another aspect of our interaction was the discussion that we had on topical subjects, or on questions that the youths would raise. What were the subjects of these discussions? "Is there life on Mars?", was a question asked during the Viking landing. In

the month prior to Ambedkar Jayanti, a serious discussion arose on the relevance of Dr. Ambedkar's teachings and the teachings of Buddha towards the emancipation of the oppressed castes. We were asked, "How did the caste system arise?"

Most of us, with an academic background in the natural sciences, were as ignorant about these questions as our students were about mathematics. We were compelled to do some new reading, thinking and discussion. Some of the other questions that led to intense discussions were: "Are the Ramayana and Mahabharata accounts of historical events or mere stories?" and "What should we do about slum evictions?"

We could also not fail to notice something that seemed to us to be an anomaly. At the time when our tuition programme was failing, a couple of our students were also attending tuition classes in English, for which they paid fees of Rs. 10 per month. And to attend these classes, they even walked a distance of over a kilometre, thrice a week. Yet they went regularly. We were curious to find out why attendance in our classes was so low, while the same boys attended the English classes regularly. Were they dissatisfied with our teaching? No it's not that, was the reply. Knowing English helps you to get a job. What use is mathematics to us? Will it help us to get a job? Obviously, we could not say yes.

One thing, however became clear. Any successful education programme in the slums would have to answer some needs felt by the participants, or else there would be no participants. Perhaps it is surprising that it took us so long to arrive at this simple realisation. It would take more time and experience to understand the implications thereof.

Reflecting on the year's experience, we realised that we had not succeeded in inculcating a scientific attitude in even one of our students, let alone broad sections of the people. But we had arrived at a clearer picture of the difficulties that we would have to contend with. We had been able to shed at least some of our illusions. In a sense, we were becoming less unscientific.

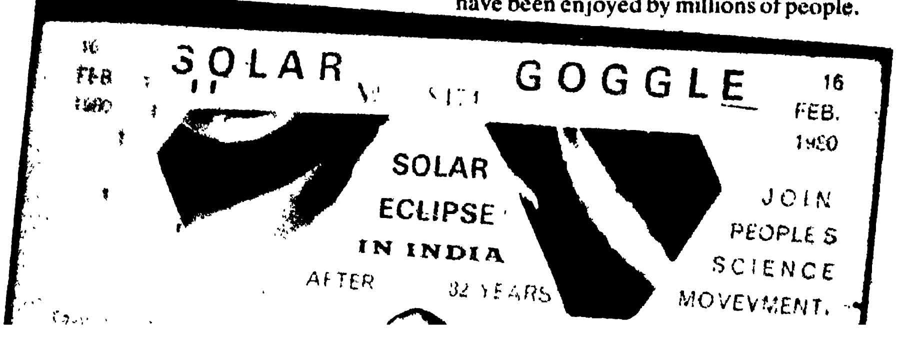
Communication established

Nevertheless all of us who had persisted with the classes were glad that we had done so. For, by now we had established friendship with the youth leaders. Because of this trust, we could get directly to the point on many issues. Our own queries would receive straightforward replies. We became aware of the internal social structure of the Bombay slums, the polarisations, the communal group-

Solar goggles

(As example of the kind of science programmes which can reach broad sections of the public, we describe here one of the programmes, the solar goggles, which was taken up at the time of the solar eclipse. It was organised by *Jan Vidnyan Kendra* all over Maharashtra, as decided at the Chandrapur meeting. Science Education Group was an active participant in the Bombay region.)

The idea of a solar goggle, a filter that allows you to look directly at the sun, originated with a 12th standard student of Gondia in Chandrapur district working at the Science Centre at Somnath. He discovered that the reflector film of their solar cooker could also be used to shield the eyes from its glare. Later this aluminium-coated polyester film was tested on a CARY 17 D spectrophotometer. It was found to transmit far less than the safe limit of a one-lakh factor attenuation stipulated by the Indian Meteorological Department and the journal, *Sky and Telescope*.



This pair of goggles is not a toy. It is a
scientific instrument which you will be able to use to
view the solar eclipse on February 16th. This total
eclipse is occuring in India after 82 years. It will
commence in Bombay at 2.19 in the afternoon. Gradually,
a part of the sun will appear to vanish.

The goggles were mass produced, with used computer cards for the frame, and strips of the above-mentioned film as filter. Each pair was further lamp-tested to ensure safety. The design was so simple that one person, working with a stapler, could comfortably make one thousand in a day. With the assistance of the Shramik Vikas Mandal in Bhandup, Bombay, thousands were manufactured in about a week. A large number of slumdwellers were involved in this effort.

We had no inkling of the tremendous response the goggles would receive. Schools in Bombay were ordering thousands each, and we were only able to supply 50 or so to most, so that there would be enough to go around. Limited numbers were distributed also in Pune, Nanded, Aurangabad, Dhule, Nagpur, Chandrapur, Wardha, Gondia, Sholapur and Goa for one rupee each in the cities, and 50 paise each in the rural areas. About 30,000 goggles were distributed in all, a small fraction of the actual demand.

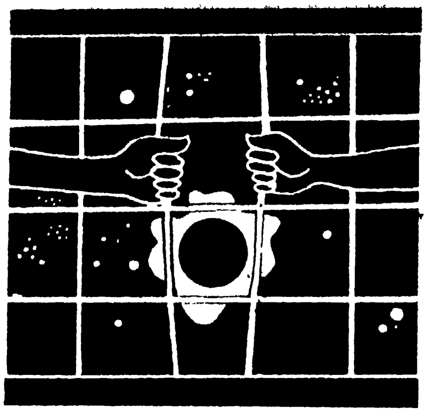
One must mention in this context, the deplorable manner in which the press treated the subject of the eclipse. All sorts of baseless statements, many of them made by scientists, had created a climate of fear around a natural phenomenon which should rightfully have been enjoyed by millions of people. The *Jan Vidnyan Kendra* tried to amend matters by giving scientific facts in a press note and a press conference. We also distributed a leaflet with each pair of goggles explaining that the wild rumour-mongering going on was a mockery of science, that with proper precautions it is safe to look at the sun whether eclipsed or not. We also refuted superstitions against eating during the eclipse and against pregnant women viewing the eclipse.

One could say that the solar goggles achieved the following objectives. (1) The slogan "Join People's Science Movement" printed on each pair in Hindi, Marathi and English was taken to the public in urban as well as rural Maharashtra. (2) After deducting costs, resources at the rate of about 30 paise each, were raised from 30,000 people, thus demonstrating in practice that it is possible to raise resources from common people for people's science activities and it is not necessary to rely on funding agencies. (The Vidnyan jatra in Prakasha, Dhule has been financed by this amount of Rs. 10,000 together with additional donations.)

ings and their mutual suspicions. We also learnt that without this understanding, the end result of any effort would be something quite other than the original objective. We learnt the importance of religious festivals as means of organising different communities. We learnt to look on religion as something other than mere superstition, studying its cultural and political role in defining relations within and between different religious communities. We experimented with discussions on the historical origins of different religions, trying to understand how beliefs and customs arose in each community, and found this to be an excellent starting point for discussion on science and the scientific method, one which the youth took up naturally and enthusiastically. Searching for source materials, we discovered D. D. Kosambi, *(Myth and Reality* and *Introduction to the Study of Indian History)* Debiprasad Chattopadhyaya (*Lokayata*) and Irawati Karve (*Yuganta*). For us too, it became, and has remained, an exciting intellectual challenge. Thus we became aware of a whole new potential for the propagation of science, a potential which is invisible to those like us who learned science from books—British, American, or imitations thereof.

From an evaluation of this experience, two lines of action emerged. First, science would have to be introduced in relation to people's needs, it would have to be useful in solving felt problems. Second, to ensure broad participation, we would have to utilise an appropriate medium. Despite the popularity of commercial cinema, we did not find the movie film to be such an appropriate medium. Finding electricity is a problem in most slums, unless one is willing to tap streetlights, and that has its attendant risks. In any case, this cannot be a regular source. Screenings have to be in some open space. If this is to be done legally, something like three permissions are required, for which a number of certificates have to be produced. The conditions for obtaining permission are impossible to satisfy (one condition is that the film should not be inflammable). So one is at the whim and mercy of the local police station. Projectors are expensive to rent, and cannot be transported by public transport, which means additional expense on transport. If the film is screened without permission, the projector is apt to be confiscated as it happened on one occasion. The local youth had to gherao the police wireless van in order to get it back. But the film show was totally disrupted.

We, therefore, decided to experiment with a simpler audio-visual medium, the slideshow. This has several advantages. Once a slideshow is



ready, scripts can be produced in any number of languages by translation. Commentators can be trained from the local slum youth. The visuals (slides), depending on the subject, could be shot right in the slum or in locations familiar to the audience. Most important, the slideshow can be constantly modified, incorporating criticisms of the audience and topical events. Our first slideshow was in fact, a most educative experience.

In the midst of the emergency, a number of slums in Bombay had been demolished. Premnagar, a slum in Worli near where we worked, was cleared up to make way for a new cinema theatre. Several others had been served with eviction notices. There was a great deal of insecurity among slum residents. What we chose for our first subject was a "burning problem" for the slum residents, one that had come up time and again in discussions—the 'problem of slum evictions.

"What should we do?", we were asked. We talked to a lawyer, and found out that an ordinance (later passed as an Act) had been promulgated to sanction the evictions. Under "The Maharashtra Vacant Lands Ordinance," once an area had been declared as vacant land and eviction notices served, no court of law could stay the orders of the Competent Authority who is empowered to issue such notices. Armed police could be used for evictions. Any offences under the Act were non-bailable, carrying a minimum of three years' imprisonment.

All these provisions were contained in explicit clauses in the text of the ordinance. Most of the slum residents were, however, quite ignorant of this. So we began our slideshow by explaining the provisions in simple language. Next we went to the question of why this ordinance might have been passed and why slum evictions were taking place. The preamble to the ordinance explains that "... the number of unauthorised occupants on vacant lands in the urban areas in the State was rapidly increasing and was causing grave danger to public health and sanitation, and peac inhabitants of such areas". We found this reasoning unconvincing. If the government was so concerned about unsanitary conditions in the slums, they could greatly alleviate, if not, solve the problem, by systematically providing sanitary facilities. We read the preamble to the youth. They replied, "Are we not inhabitants? If not, then what are we?" Such questions were incorporated into the slideshow. They felt that the real reason for slum evictions was that the 'paisewallas' wanted the land for other purposes. Looking into the facts of the matter, we also concluded that their assessment was quite realistic. Premnagar nearby had been demolished to make room for a cinema theatre. A huge slum in Anushaktinagar, Janata Colony, in which 70,000 people reportedly used to live, was evicted to make room for a recreation centre for the residents of the Bhabha Atomic Research Centre Colony.

All this necessitated that we trace the growth of slums in Bombay, showing how workers migrating to Bombay from rural areas were compelled to find shelter by putting up huts in pieces of unwanted land; how, with the growth of industry and commerce, the city expanded and what was 'unwanted land' 50 years ago has today attained a high value and is much in demand for putting up factories, residential complexes, shopping centres, offices, etc. We found in this a more realistic understanding of why slums are being evicted. Towards the end of the slideshow, we posed the question, "What should the slum-dweller do?" We pointed out that under the Act, eviction orders could not be challenged in court and that they had no alternative except to organise to resist eviction. The slideshow also made a statement about the tremendous numerical strength of the slum dwellers which would be very difficult to oppose if organised on this issue. But this strength was unrealised because people instead dissipated their strength in mutual strife on issues of caste, community, region and language.

However, when we started showing the slideshow, several problems came to light. First, we hadn't anticipated the size of the audience that each show would attract. We had made the slideshow in two parts, the first part was to be followed by a discussion. The second part was designed to answer questions that we anticipated would arise in this discussion. In practice, nothing like this was possible. How do you conduct a discussion with a crowd of 300 people of whom 200 are young children? With such a crowd and the children sitting in front, the adults in the back

Surya jatras

EVERYWHERE in Bombay the streets were empty of people and traffic. We had a hard time reaching the venue of our *Surya jatra* being held in Chembur. The previous *jatras* on 14 March with the Shramik Vikas Mandal at Bhandup and on 15 March at the Mass Movement Office at Pestom Sagar, Chembur, had been such a rousing success that we decided to extend the jatra to the day of the eclipse.

The *jatra* itself was a modest affair. There was a practical demonstration of cooking on a paraboloid reflector-type solar cooker. We cooked 3/4 kg rice in 25 minutes, baked eggs without using water in 15 minutes and made omelettes. We also demonstrated the Fresnel lens and the pinhole camera. There were photographs of the shadow of the moon on the earth taken by a NASA satellite during the total solar eclipse of 7 March 1970. A pictorial exhibition consisting of 50 posters on the subjects "We and the Sky" and "Man and Astronomy" was exhibited. A working model of the earth-moon system showing how the eclipse takes place was demonstrated (the model was based on the original developed by the Vidyamandir Prashala, Brahmanpuri, Miraj, a prize-winning exhibit at the 1979 all-India exhibition organised by the National Council of Educational Research and Training) The solar cooker and the "Miraj model" were great draws, while the poster exhibition stimulated people to ask questions.

Would people show up? Most of us were confident that the last day would also be a success despite the government statement in bold letters in the morning papers warning people to stay inside during the eclipse, and under no circumstances to look at the sun.

At around 2.15 pm, there were only about a hundred people near the *mandap.* Most of them were looking at the sun expectantly through the solar goggles (see box on p. 37) we had distributed. Final touches were being given to a booth being constructed with its entire roof made of metallised polyester sheets used in the solar goggles.

The children who had gathered around were all given little pieces of mirror glass and shown how to project the image of the sun. As the eclipse began, excited kids ran home to show off their new discovery.

Soon someone had projected a big one-metre-wide image of the eclipsed sun with a mirror on the wall of one of the five-storey buildings opposite the *jopadpatti.*

Many people came out to have a look at this. Over the loudspeaker we invited them to take a direct look at the sun through our 'Surya booth'. Seeing the long queue in front of the enclosed structure, hundreds of slum residents were encouraged to shed their fears and break the old taboo.

What psychological effect this may have had is hard to specify, but many people went back home to bring out those inside. The place got packed with people and everybody was clamouring for a solar goggle. We had run out of stock the previous day so we asked people to share theirs.

With this new enthusiasm, the *Jan Vidnyan Kendra* volunteers had a quick consultation and decided to go one step further. We asked the people gathered there to join us in the breaking of the taboo against eating food during the eclipse.

We bought lot of bananas, biscuits and two dozen eggs. The eggs were cooked on the solar cooker, and distributed. The bananas and biscuits were also distributed free. Despite the enthusiasm, there was a remarkable sense of discipline and no confusion. Perhaps people felt that they were participating in a symbolic event and it had to be done with dignity. You start, they told us. We did, and several hondred of the slum residents joined us.

The pinhole camera model, an indirect way of looking at the sun

Very few people remained inside their huts. Even women came out in large numbers, including one pregnant woman, who also took a look through the 'Surya booth'.

With its thousands of mirrors, the solar cooker was used to project a mosaic of eclipses on the building wall. The crowd enjoyed the spectacle, especially when the cooker was spun on its axis and the mosaic spun in its turn.

One of the youth volunteers took the microphone and shouted: *Andhashraddha vadnaarya vaidnyanikaa cha dhikkar aso* (We condemn those scientists who spread blind faith and superstitions). The crowd responded: *dhikkar aso, dhikkar aso.* At that time, of course, we could not inform the residents of Pestom Sagar (since we ourselves did not know of the fact) that many of the scientists who had gone to observe the eclipse in its region of totality, including several reputed solar physicists, had refused to eat biscuits offered to them, during the eclipse.

We feel that this little event, on the day of the eclipse, has a wider significance. Pestom Sagar is an average slum, in no way special, not much different from the thousands of slums in Bombay. How is it that virtually the entire slum turned out to watch the eclipse directly when all over the country crores of people hid in their houses, leaving the streets deserted? Clearly, the common people are not as fear-ridden and conservative as are some scientists. With a little encouragement, with a little showmanship, it is possible to elicit, en masse, their participation in a scientific event. The *Surya jatra* was a simple affair, costing only a few hundred rupees to set up. It should have been possible to set up such exhibitions all over Bombay and thus bring out lakhs of people to view the eclipse and shed their superstitions. In fact, this could have been done all over the country, mobilising the school and college network.

Why can't this be done in 'future? Events like the fall of the Skylab, and the total solar eclipse, are treated by the mass media in such a manner as to create mass fear. Dispelling such fears and exposing the interests behind them can be a most powerful method of propagating science, and turning the tables on the vested interests. Halley's Comet which will be seen in 1986 will undoubtedly present such an opportunity. A national anti-superstition campaign, utilising astronomy, lunar eclipses, etc can begin now, growing in force, and culminating in a massive co-ordinated effort reaching both cities and villages six years from now. We would welcome getting in touch with all those interested in organising such a campaign.

V. M.

could hardly hear the commentator shouting as loud as possible, above the chatter of the kids.

Next was the language problem. We had written the first script in Marathi. In most slums, non-Marathi sections together formed a majority. This problem was solved with the help of a professional film script writer who refashioned the whole slideshow form, tightening it up, and using Bombay-Hindi, the language that the polyglot slum residents have evolved to communicate among themselves. Not only was this understood by everybody but the novel approach struck a resonance of humour which made an immediate difference on how people viewed the show. Now it 'connected', so to speak, despite its many flaws (too long, too abstract an argument) which came to light with further use.

"What should we do?"

One question which came up at almost every show we held, we had no answer for. Invariably we would be asked: "What you have said is quite correct, but what should we do?" We thought that we had answered the question when we said 'organise', but evidently this was not enough. There are many organisations working in the slums, they told us, and which one should we join. We ultimately did not go into this question because of the enormous work involved in arriving at a scientific assessment of which, if any, of the organisations, most of them political, was in the best interests of the slumdwellers to join. Moreover, we felt that this question could not be answered without active experience in this field.

As we proceeded to exhibit the slideshow in different slums, we came across a most unexpected problem. In many slums, especially those on private lands, the slum tenants were organising themselves to demand that their area be declared as 'vacant land' under the Act. The slumlords on the other hand, were demanding that the Act be rescinded. It took us some time to understand this peculiar state of affairs. It turned out that under the Act, the slumlord forfeited his right to collect rent from the tenants, as also his right to evict (by court order) tenants for non-payment of rent. Faced with a choice between immediate eviction by the landlord and the threat of distant eviction by the government, slumdwellers on private lands opted for the latter. The majority of slums in Bombay being on private lands, we were compelled to 'withdraw' our slideshow for considerable modification, rather than go against the interests of millions of slumdwellers and play into the hands of slum landlords. Once again, the indispensability of concrete field experience was compelled upon us.

A different kind of objection came from some middle class viewers. This is not science, they said, this is politics. We asked them to point out what they felt was unscientific in our argument. It's not that, they replied, the subject does not lie within science.

We discussed this objection thoroughly within the group. Are not slums and slum evictions part of reality? Why should science turn a blind eye to certain parts of reality? Should social questions be excluded from the realm of science? If so, then how is science, and the scientific attitude to be propagated among the masses? If we accept that any mass education programme must be relevant to the needs of the learners, can we deny the consequences of this truth? Supposing, instead of evictions we had taken up water, another 'felt need' of the slumdwellers. The questions that they would be interested in would be something like this : "Why don't we get sufficient water to drink and wash our clothes? How can we get more water?" Supposing we started answering these questions, should we get into the problem of water distribution in Bombay, into why some areas get water 24 hours a day and more besides for gardens and swimming pools, and why others get no water at all? Or is that unscientific?

In our group we decided that, quite the contrary, it would be unscientific to ignore such questions. If we are at all serious about mass education, then we have to begin with what the masses are concerned about. If these concerns—problems like caste, slum eviction, water distribution, health, etc—lead us to areas with socio-political implications, then these implications, in the interests of science, cannot be suppressed but must be investigated scientifically.

Fundamental change

When we talk about propagating a scientific attitude in the masses, we are talking about a fundamental change in mass consciousness. Such changes are not common and occur once in a few centuries—and they are always brought about by mass movements, like the Buddhist or the Islamic cultural revolution, the sixteenth century Bhakti movement, or more recently the Satyashodhak movement in Maharashtra, during the late nineteenth and early twentieth century.

The question we, therefore, have to face is, Can science become a mass movement? Why cannot a programme of education be built around the problems of the masses; the problems of food, housing, water, work, health ...? But how is this to be done? It is not enough to [redacted] viduals thinking in these terms. How can science education become a social process?

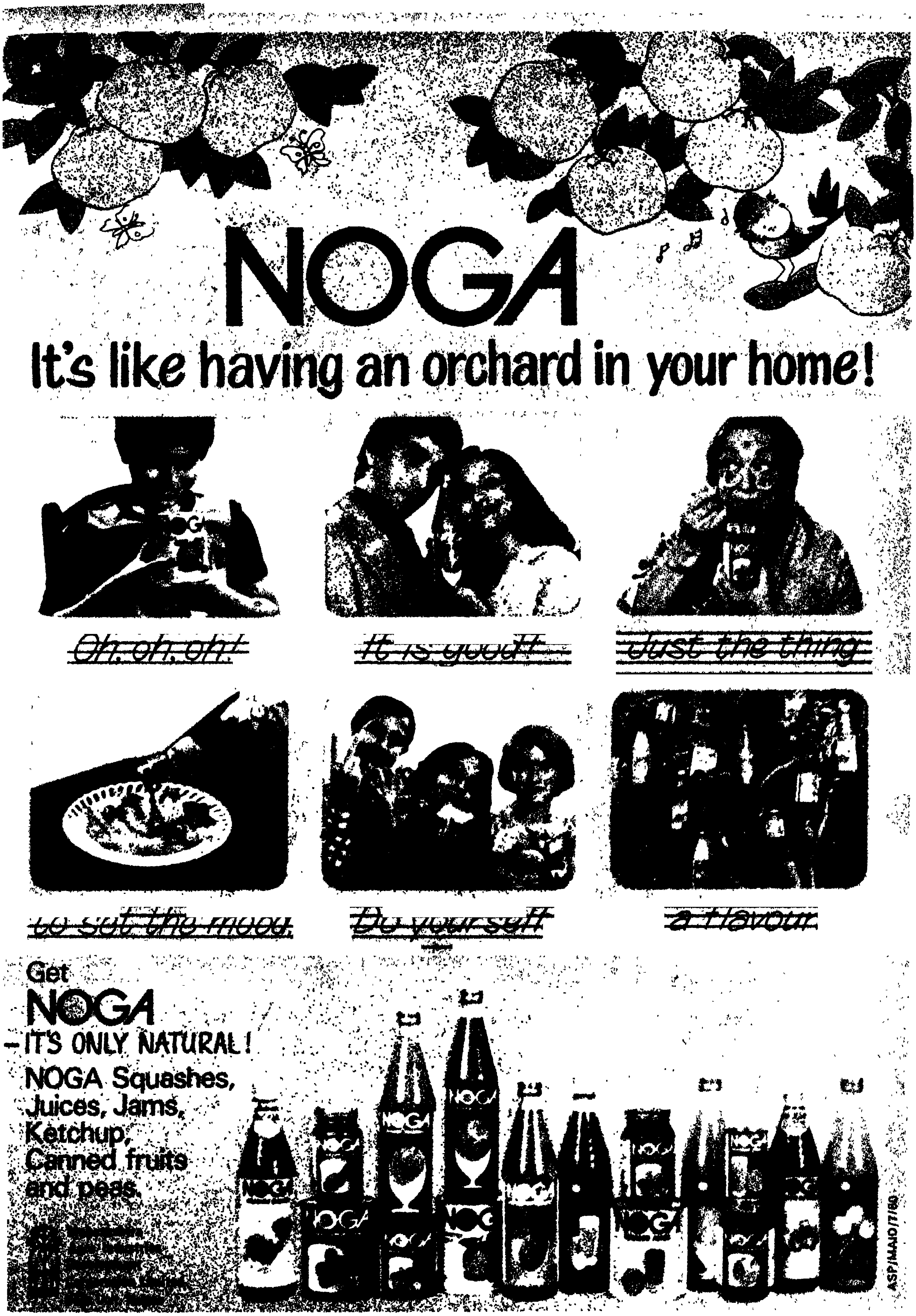
Our teaching experience led us to questions of this kind. It was at this time that we received an invitation to attend the "All India Convention of People's Science Movements" in November 1978 in Trivandrum, hosted by the Kerala Sastra Sahitya Parishad. We were greatly encouraged to find many other individuals and groups there who had arrived at similar conclusions. Despite differing perspectives on a number of questions, there was common agreement on two planks: first, the need to make a thorough critique of existing science, its scope and method, and second, the need to end the monopoly of the elite on science, to build a 'people's science'.

The following year, in 1979, a similar meeting was held in Somnath in Chandrapur district, Maharashtra, and an ad hoc body, *Jan Vidnyan Kendra*, was formed to co-ordinate different people's science activities in Maharashtra. Our first such joint effort was around the solar eclipse in February this year when *Surya jatras* were organised in a number of places. A more comprehensive *Vidnyan jatra* was held in April 1980 in the advasi taluka of Shahada in Dhule district. The Science Education Group has been an active participant in both the above programmes.

What we hope to obtain from this is a better understanding of the problems of communicating science, what sort of things people find interesting and stimulating. A more basic task is, of course, to establish a network of active like-thinking groups, working with a common programme. This will take some time to grow and we hope that the *Vidnyan jatra* will help towards this end in Maharashtra.

We feel that as a first step towards building a people's science movement two sections need to come together—the scientific intelligensia, who are fed up with the elitism and market place values of the modern science establishment and who feel the need to democratise science, and second, organisations working among the masses who realise the need for their members to think clearly and scientifically. There are a number of such organisations, and each activity like the *Vidnyan jatra*, brings us into contact with more. It is already clear that there is a lot of potential. Whether or not it can become a movement is still an open question.

Dr. Monteiro is with the Science Education Group in Bombay. A physicist, he is also involved in trade union work.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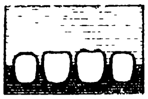
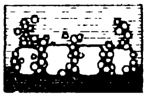


Odour and decay causing bacteria grow in food particles trapped between your teeth.



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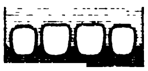

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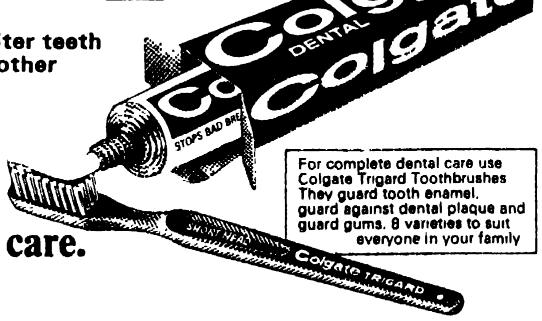

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can give you better dental care.

Dual densitometer for quality control of films

IN AN aerial black-and-white photograph, the different levels of soil moisture in a terrain, the various stages of growth in a crop, the varying qualities of water bodies in a scene — all appear as different intensities of grey. These have to be reproduced exactly for correct interpretation. Where the required image quality is to be produced repeatedly, as in aerial photography, remote sensing and image processing, consistency of the copies becomes important.

Different photographic films and papers respond differently to the same incident light and thus create different densities on them. Normally the density range is 0 to 4D for transparency films and 0 to 2.5D for paper prints. For measuring the density of transparency (film) a certain amount of light from a standard light source is made to transmit through a small portion of the film, called the resolution element, and the transmitted light through that spot is measured. Then the density at that spot is given by.

$$D = \log_{10} \frac{\text{Incident light intensity}}{\text{Transmitted light intensity}}$$

For hard copy prints, the reflected light from the spot due to an incident light at that spot is measured and converted into density units.

To measure the optical density of a photographic film transparency or a hard copy print for quality control, densitometers have been developed. A few companies make densitometers for black-and-white and colour applications, which have a density range of 0 to 4.0D for transmission and 0 to 2.5D for reflection. Indigenously available densitometers measure density of black-and-white transparency (film) with one resolution only. The National Remote Sensing Agency, Secunderabad, has now developed a densitometer which, it is claimed, can measure film transmission densities (black-and-white as well as colour) and reflection densities of photographic prints within the ranges of 0 to 4D and 0 to 2D, respectively. The densitometer is used in quality control of aerial photographs, computer generated films, graphic arts, biomedical applications and in sophisticated photo laboratory for sensitometric work.

The NRSA densitometer is a digital readout photometer and of dual type. Measurements taken with the densitometer indicate diffuse visual and opal-glass density. A three and a half digital display with polarity indications facilitate accurate and reproducible readings. The densitomer has a stable halogen light source, a photomultiplier (PMT) as detector solid state circuits, and compact mechanical assembly. The incident light flux from the highly stable light source transmitted (reflected) from a film (hard copy) is collected by an optical system and impinged on to the cathode of the PMT which in turn produces a current that is proportional to the amount of light energy striking the cathode. The output current of the PMT is properly amplified and converted to optical density units and are displayed on the digital display (Fig. 1 & 2)

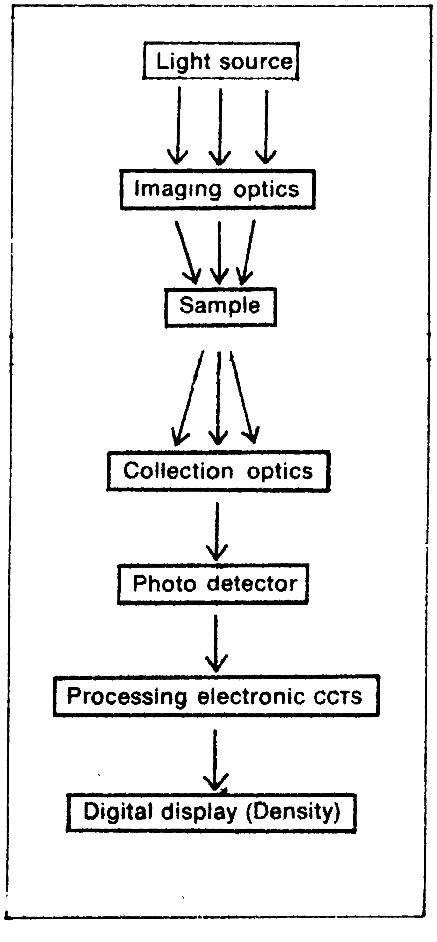
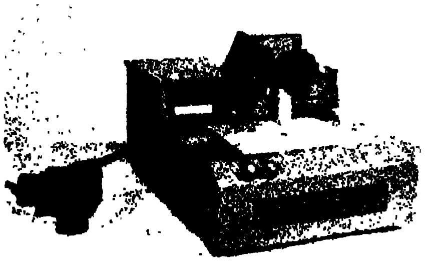


Fig 1 Transmission densitometer



The NRSA densitometer

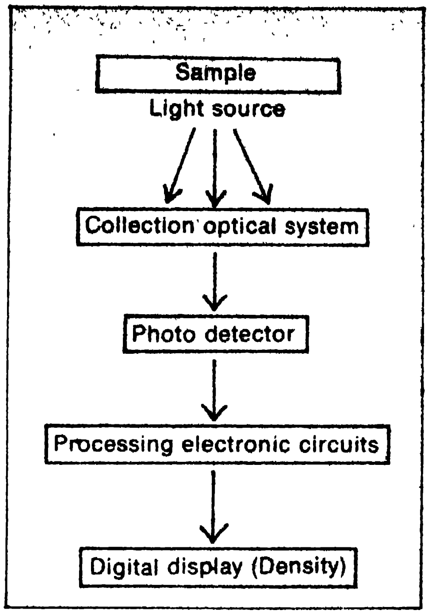

Sample
Light source
Collection optical system
Photo detector
Processing electronic circuits
Digital display (Density)

Fig 2 Reflection densitometer

The densitometer has been calibrated with a 21-step gray wedge scale and the graph between the wedge density and the corresponding density values as measured by the NRSA densitometer is a straight line with an accuracy of ± 0.02D.

The densitometer has an illuminated viewing area of 23 x 23 cm, dispensing with the additional light table for analysing aerial and remotely sensed films. The transmission system has three usable resolutions, that is, 1 mm, 2 mm and 3 mm, while the reflection system has one resolution, 5 mm.

Specifications.

Size of input:	Sheet films measuring 23 x 23 cm or aerial film rolls and hard copy prints of any size
Type of input:	Black and white or colour
Detector:	Photomultiplier
Source:	Tungsten halogen lamp
Density range:	0-4D for transmission (black & white/colour) and 0-2D for reflection (black & white) optional
Resolution:	1 mm, 2 mm and 3 mm for transmission and 5 mm for reflection
Accuracy:	±0.02D
Output indicator:	3½ digit LED digital display
Display reading rate:	5 samples/second
Calibration:	By a film step wedge
Input power:	60 watts 230 ±10% AC, 50 HZ
Dimensions (in mm)	600 (H) x 390 (W) x 320 (D)

A.K.S. GOPALAN

Dr. Gopalan is with the Space Applications Centre, Ahmedabad.

A peek into Silent Valley

SILENT VALLEY, the site of the 120 MW hydel project in Kerala's Palghat district, is an ecologists' nightmare. At stake is India's last near-virgin tropical rain forest. According to ecologists, the project threatens the multitude of plant and animal species that have evolved in the tranquillity of Silent Valley for six million years. Many of these have yet to be systematically catalogued. From the plant species studied so far, thousands of medically applicable drugs have been isolated. Further, the Valley is the last habitat of four endangered animal species—tiger, panther, lion-tailed macaque, and the Nilgiri langur. If this rain forest is destroyed — which the conservationists are convinced the hydel project will surely do — there will be drastic changes in rainfall over major agricultural zones not only in the Western Ghats, but over the entire continent.

The project's proponents, the Kerala government and its scientist supporters, have been dismissing all this. They accuse the other side of indulging in "ecological luxuries". Their version is that only 900 to 1,000 hectares of the nearly 9,000 hectares of evergreen forest will be affected. And though at present Kerala is a power exporter, the 120 MW that the Silent Valley project will generate may not be sufficient to meet the State's power needs by 1985. Under pressure from the Department of Science and Technology, and widely publicised attacks through the media, the State has promulgated an Act to safeguard the Valley. It has also set up a body to watch over the project and has invited eminent ecologists as members. Two invitees have refused to participate; they feel the safeguards are inadequate and the committee can do little more than present a tragic post-mortem report.

Other concerned scientists are working out alternatives towards providing Kerala with power as the debate has taken on an ecology-versus-development character. Meanwhile, the Kerala government has promised a national seminar, hopefully to break the impasse. But the composition of its participants has invited criticism from the Save Silent Valley Group. A 'spokesman for the scientific community' says that the conference is "stage-managed" to get the centre's approval for the project. •

F. C.

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2

3

4

1 A hillock, partially denuded of its trees, stands as if in warning against what may happen to Silent Valley

2 Early morning over the Valley

3 A million species of plant life live under the canopy formed by the tree tops. Shown here is the *Lycopodium* sps, a fern

4 Fast-flowing streams and tiny brooks, such as this one, were found to be the environment of two hitherto unknown types of fish, and the limbless amphibian, *Caecilian,* which had been presumed to be extinct

5 Tall trees dwarf a man. More than a hundred varieties of trees are to be found in an average acre of a rain forest, compared to ten in a temperate forest

6 *Thumbergia mysorensis,* a climber in florescence

7 A snail from the Valley. Different kinds of butterflies, dragonflies, beetles, mayflies and grasshoppers are found in Silent Valley

8 *Pilea caderei,* a shade-loving plant, typical of tropical rain forests

Photographs: David DeSouza

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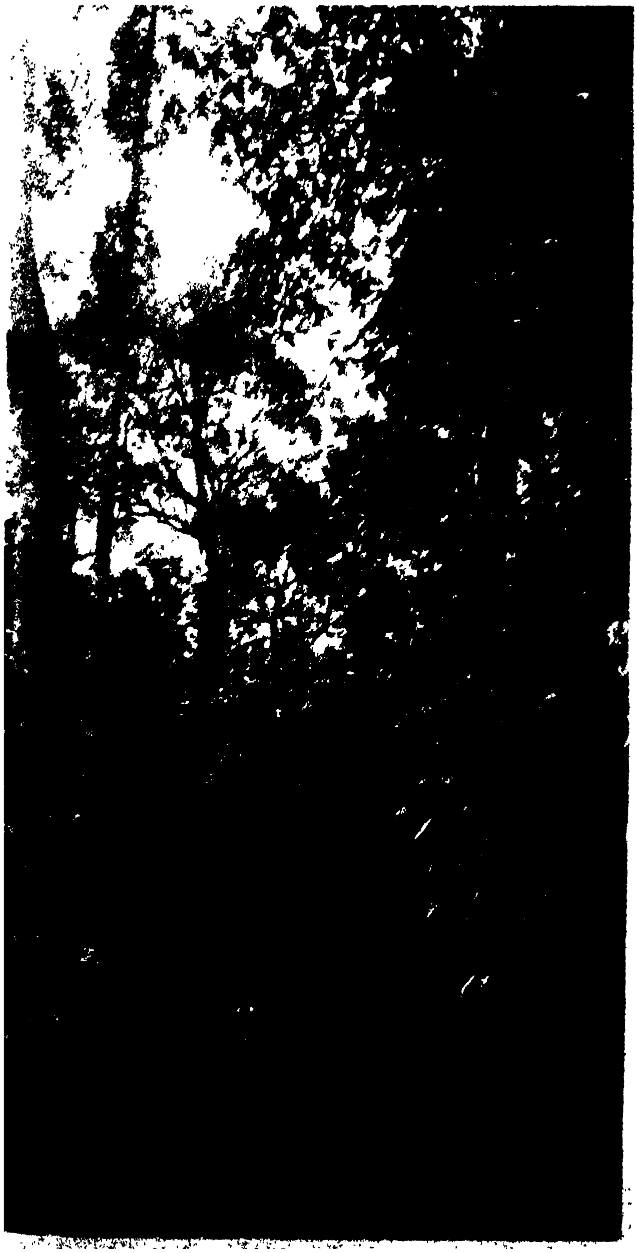

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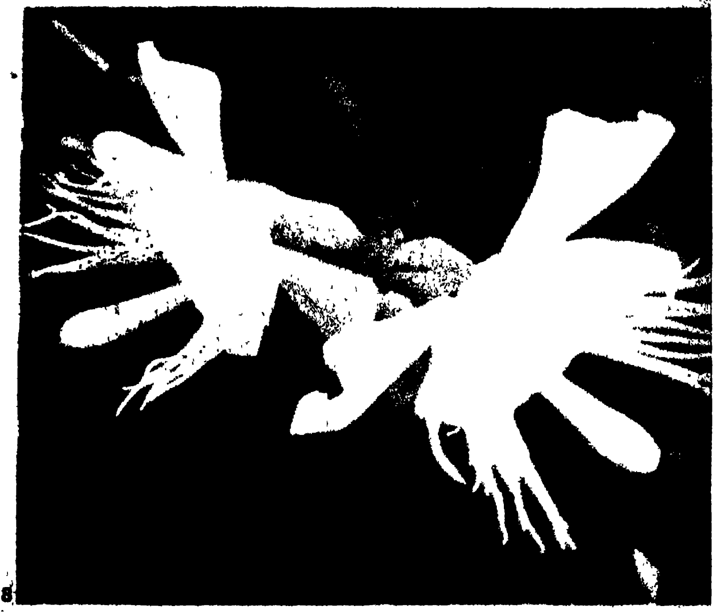

8

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If...

... Planck's constant had a different value

PLANCK'S constant is recognised as a fundamental constant. It arises in quantum mechanics and is the unit of action. It was introduced by Max Planck to explain the spectrum of the heat radiated by hot bodies. He postulated that light energy comes in packets called quanta. The energy of one quantum of light of frequency ν is given by $E = h\nu$ where h is the Planck's constant. Its value is 6.6256×10^{-34} joule-second. Einstein used this idea to describe successfully the photoelectric effect.

Since all observed physical quantities like, say, the density of water at room temperature or the colour of gold, can be expressed in principle as a formula involving h, the mass of an electron m_e, the mass of a proton m_p, and the velocity of light c, it would be possible to ask what would happen to these things, and others, if the value of h were slightly different. This question can be answered meaningfully, unlike the question: What would happen if $2 + 2 = 5$?

Let us imagine a world in which the value of h is larger than in ours by a small amount, say 10 per cent.

To begin with, let us consider the properties of atoms in this world. The simplest is the hydrogen atom; it consists of an electron and a proton. The interaction between a proton and an electron is the electrostatic Coulomb attraction. According to Bohr's theory (or quantum mechanics), we know that the atom can exist only in discrete stationary states. In the lowest energy state, the size of the atom is $h^2/(4\pi^2 m_e e^2) \simeq 5{:}2 \times 10^{-11}$ metres. Therefore, in the new world of a higher Planck's constant, the hydrogen atom would be bigger by about 20 per cent. The binding energy o the hydrogen atom, that is, the energy required to remove an electron from the lowest energy state of the hydrogen atom to a free state, is given by $2\pi^2 m_e e^4/h^2 \simeq 2.17 \times 10^{-11}$ ergs. Since this varies inversely as the square of h, the binding energy of hydrogen atom would be less than its present value by about 20 per cent. This can be understood qualitatively as follows: increasing the value of h increases the kinetic energy of the electron, which is proportional to h^2, and hence decreases the binding energy.

Determining the properties of more complicated atoms requires more work. However, ratios of sizes of atoms are independent of the value of h. The size of a helium atom is now about 0.7 times the size of a hydrogen atom. In the new world, both the hydrogen and the helium atoms will be bigger by about 20 per cent, but the ratio will still be the same as in our world.

Another effect of such an increased value of h would be a slowing down of all processes as compared to those of our world. We know that atoms in molecules are not at rest and jiggle about their mean positions. All such vibrational frequencies would decrease by about 30 per cent. This would imply in particular that atomic clocks would run slower than they do in the present world.

Also, boiling and melting temperatures of materials would decrease. Liquids boil at a temperature at which the thermal motion of their molecules becomes comparable to the intermolecular binding energy. An increase in h will cause a decrease in binding energy and consequently boiling points of liquids will be 20 per cent lower.

We can also easily determine the effects of variation of h on strengths of materials easily. The Young's modulus is of the order of typical electronic energies divided by the typical atomic areas. This means that the Young's moduli of materials scale as h^{-6} and hence all things in this world would be about 40 per cent more brittle.

If a planet in this set-up were to have the same mass as our earth, its radius would be 20 per cent larger. As the acceleration due to gravity at the surface of a sphere varies as the inverse square of the radius, the gravity at the surface of this planet would be 30 per cent less than on the earth. This means that our counterparts (if they exist) would find it easier to move around on their planet than we do on the earth.

So far we have found that all quantities in a larger h world can be obtained by a simple scaling of their counterparts in our world. This is not really surprising and is a consequence of the fact that these are determined essentially by the elctrostatic interaction between electrons and nuclei and the electrostatic energy between charges is a simple power of the distance between them.

These small differences between our world and the world of higher Planck's constant might not sound very interesting, and we might ask whether anything would really change very much in the universe if the value of h were larger by 10 per cent. Surprisingly enough, it turns out that in this world of larger h, the sun would generate about the same amount of heat but the boiling point of water being much lower, oceans would boil away and get converted to steam.

To see how this comes about, we have to consider the sub-nuclear processes in this new world. We know that the sun produces its energy by nuclear fusion, that is, by converting its hydrogen into helium. This reaction occurs in many stages, but the crucial step (determining its rate) is the formation of deuterium in the sun by the coming together of two protons. In this process, a positron and an antineutrino are also created.

The rate of this $(p + p \rightarrow D + e^+ + \bar{\nu})$ reaction depends on two factors. One is the electrostatic repulsion between the protons which reduces the likelihood of their coming close enough to form deuterium. The other is the probability that one of the protons gets converted into a neutron, emitting a positron and an antineutrino, and the rate of this process varies as h^{-7}. Increase in h increases the first factor somewhat, and compensates for the decrease in the reaction rate due to the smaller probability of proton to neutron conversion. As a result, the net deuterium production in the sun remains essentially unchanged. The solar power per unit area incident on an earth-like planet of increased h, will be the same as ours. (A slightly more accurate calculation shows an increase of about 6 per cent in the solar power output.) Here we have assumed the distance between the sun and the earth in this world is the same as in ours.

The average ambient temperature can be calculated by assuming that on an average it should radiate as much energy as it receives from the sun. Since the sun's radiant energy varies as the fourth power of the temperature, the absolute temperature of an earth-like planet in this new world would increase by a factor $(1.06)^{1/4} = 1.015$. Taking 300°K to be the value for the ambient temperature of our earth, we find that the average temperature of the aforementioned earth-like planet would be about 304°K. But this is more than the boiling temperature of water on this planet, which would be only 302°K. Hence all oceans on this planet will boil away.

Similarly, if h were less by 10 per cent, the oceans would freeze and life as we know it would perhaps not exist on the earth.

DEEPAK DHAR
ROHINI M. GODBOLE

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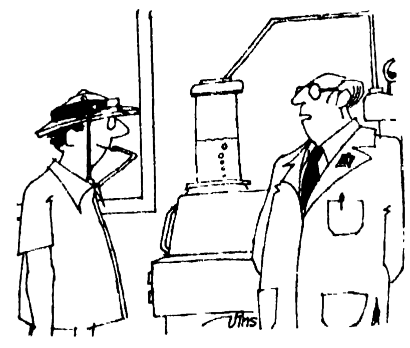
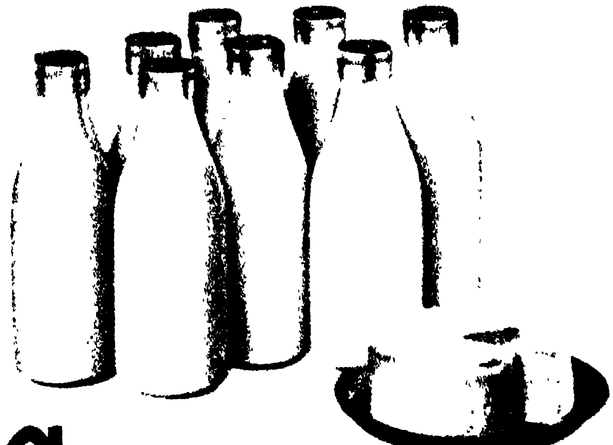


"You prevent sun-stroke by blowing air to circulate the water inside the sola hat."



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Two books on computers

Computers — Genesis, Programming and Applications by N. Subramanian, Wheeler, 1979, 280 pp. Rs. 36.

Principles of COBOL and FORTRAN Programming by N.K. Masani, Progressive Corp., 1979, 264 pp. Rs.19

THE LATTER half of the seventies saw, in India, a sudden spurt in the demand for computer professionals. This demand could not be adequately met by the teaching institutions in the country. The obvious result was the mushrooming of specialised short-term training courses, particularly in system analysis and standard computer languages. But most of the courses were, and still are, handicapped by the non-availability of good and cheap Indian books on these subjects. The release of new books is thus to be seen against this backdrop of ever-increasing demands for trained computer personnel on the one hand, and, on the other, the thoroughly inadequate training infrastructure both in the academic and commercial fronts.

A glance at Dr. Subramanian's book suggests that it does justice to the title—that it is a textbook on programming and applications. After devoting a chapter each to history and computer hardware, programming and flowcharting, the author proceeds to present FORTRAN in four chapters spread over about 100 pages. This is followed by a chapter on COBOL and then one on BASIC. The reader is likely to get misled by the chapter headings of 'Plotters' and 'Computer Graphics'; in the former case, the fears of lengthy descriptions of plotter technology is allayed by an interesting treatment of plotting utilities on IBM systems, whereas in the latter case, the anticipation of recent trends in the area of computer graphics software technology is shattered by a dull narration of graphics terminals and historical sketches.

An unnecessarily lengthy chapter on job control language stands out like a sore thumb in an otherwise general treatment of programming. To compound this feeling, there are two appendices at the end related to machine/system specific details which is best learnt from a reference manual. The emphasis on FORTRAN is rightly carried along through the last two chapters where several numerical analysis and matrix algebra problems are stated and programmed. There is a general sprinkling of exercises at the end of chapters. A few useful appendices and solutions to selected exercises at the end of the book add to its usefulness.

One of the plus points of the book is the large number of FORTRAN programs/examples presented in the chapters on FORTRAN, matrix algebra and numerical analysis. There is however a total absence of finesse in the way the program statements are presented. Typical examples of this are splitting of alphanumeric texts into two lines, arbitrariness in the use of b̸ for a space character, poor spacing between lines and the absence or sparsity of comments. Major typographical errors (for example, paragraph name starting in margin B on p.161 and FORMAT in p.220 accounting for 176 characters) should have been avoided. The chapters on COBOL, BASIC and computer graphics do not serve any meaningful purpose. Another serious lapse in the handling of the languages, FORTRAN and COBOL, by the author is the omission of references to ANSI standards of these languages. Placing the presentations in the overall framework of these standards would have greatly enhanced the credibility of the book. In spite of these deficiencies and the high price, Dr. Subramanian's attempt at bringing out a book in an usual but effective blend should be commended.

The second book, says the author "is intended for undergraduate courses in computers and can also be conveniently used for post-graduate courses in business management". The three-part book starts with the operational details of key punch, verifier and sorter and discusses, in the first part, the different parts of a computer system, binary number system and flow charting. The second part deals with COBOL language and the concluding part is on FORTRAN.

Any discerning reader would find it difficult to endorse the author's claim about the use of the book even for an undergraduate course. The treatment of COBOL can be passed off as satisfactory though there are serious punctuation and indentation flaws throughout the chapter. These errors can have disastrous consequences to a beginner who exclusively depends on this book.

The treatment of FORTRAN is very casual and, in many places, erroneous. To cite some examples: (a) A sample program which reads data cards in an indefinite loop does not account for the end of file situation. (b) The misleading description of the logical IF statement. (c) The use of square brackets in place of parentheses.

The names of library functions (SQRTF, EXPF, etc.), the mandatory nature of the STOP statement in the program examples and the input/output statements of the form READ INPUT TAPE... suggest an obsolete version of FORTRAN language. One would expect some flavour of the latest ANSI standard version of the language from a book published in India as recently as 1979. The typographical quality of the book is also extremely poor. In the opinion of the reviewer, the book will do more harm than good as a text for an introductory course either in FORTRAN or COBOL.

P. SADANANDAN

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Brain Teasers

Awards gone awry

In the Republic of Ramrajya the President was giving away the awards for truth, love, non-violence, kindness and forgiveness to five saints named Truth, Love, Non-violence, Kindness and Forgiveness. Strangely enough, none of these saints has the quality denoted by his name, and since there was a mix-up, the awards and qualities did not correspond with one another. Also, no one got the award denoted by his name. Truth received his award immediately before the forgiveness award was given to the truthful saint and the forgiver got his award after Kindness got his love award. The award for truth went to the saint with love, and Forgiveness was a kind saint. Can you find out who got which award and what was his quality?

V. A. SHENAI

(Solution next month)

Solution to last month's Brain Teaser

School Fees

Let each boy pay Rs. b and each girl. Rs. g, so that $9b+16g=220$......(1)

Simplifying,

$$b = \frac{220-16g}{9} = 24 - \frac{4(4g-1)}{9}$$

For b to be a positive integer,

Since $4g-1$ is divisible by 9 and since $4g$ is even, $4g-1$ is odd. Hence $\frac{4g-1}{9}$ is odd, making it either 1, 3 or 5. With 1 and 5, g is not a whole number. So $\frac{4g-1}{9} = 3$, making $g = 7$.

Substituting this in Equation (1), $b=12$. So each boy pays Rs. 12 and each girl Rs. 7.

The defence of the human body

The body's immune system, which combats disease, has remarkable parallels with a defending army

G. P. Phondke

THE Marathi saint Tukaram, in one of his famous *abhangas* has said, "*Ratran din amha yuddacha prasanga.*" Translated into English, this means "Every single moment of our existence we are in a state of war." Tukaram was, of course, speaking metaphorically about metaphysical matters. But even in the physical sense his couplet makes good sense. Since hardly any spot in the world is germ-free, we are at war from the moment we are born into this germ-laden world. The enemies are the miniscule microbes, which are omnipresent in food, in water and in the air. Pathogenic microbes come in a multitude of forms, and there are many ways in which these microbes can attack the human body by bringing disease to it. To protect itself from the assaults, the body has an excellent defence system, with well-organised units of lymph nodes scattered at strategic points in the body (Fig. 1).

Some people lack this internal defence system, which is also known as the immune system. These immune-deficient people succumb to infection early in life unless their immune system is artificially built up. This is sometimes done, in addition to other therapeutic ways, by passive immunisation wherein antibodies formed in other individuals are transfused. When this is not possible, the person can survive only if he is kept in a germ-free sterile environment (see photo on p.51).

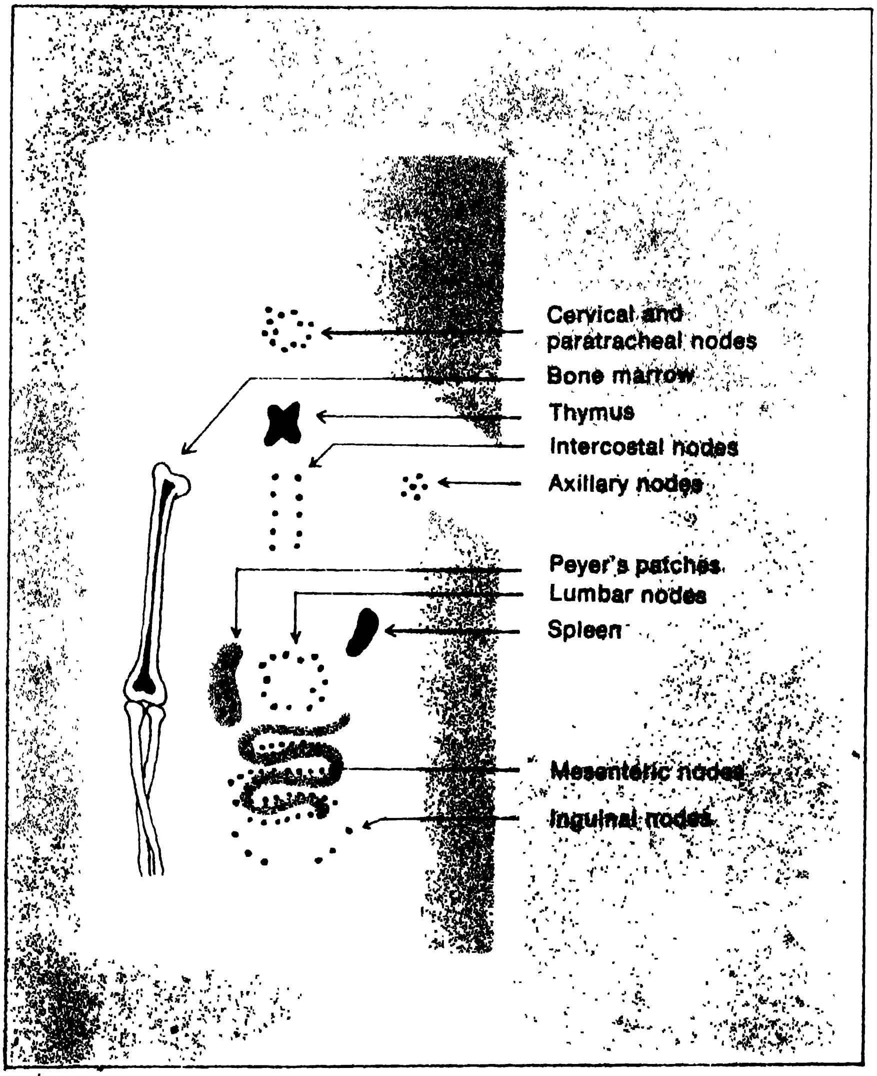
This internal defence system could well make an ideal model for any nation to pattern its own defence services on. The basic constituent of any defence force is the sentinel and this job is performed in the human body by the lymphocytes, one of the types of leucocytes or white blood cells found in the blood. The bone marrow, barring a short period immediately after birth, has the ability to generate most of the blood cells, including the lymphocytes. Therefore, it can be considered as the recruiting centre for the body's soldiers.

Since these new recruits are raw, they need training to shape them into alert and well-equipped sentinels. This training is given in two stages. The generalised training of the first stage, whereby obedience and discipline are inculcated, is provided during the formative period in the bone marrow itself. The generation of lymphocytes from their precursor stem cells is in itself a process which readies them for the specialised training.

The nature and extent of further advanced training depends upon the special duties that the graduate would have to perform in later life. For example, training for the infantry is quite different from the training for the artillery force. There are two such well-identified training centres. One is the thymus—a bilobed gland located near the lungs just above the heart. Some of the lymphocytes sojourn briefly through the thymus before getting seeded in the peripheral lymphoid organs. Here they mature and during the process undergo structural as well as functional modifications. Consequently, the cell surface properties of such mature cells are different from those of either the immature cells or the cells which constitute the thymus itself—the structural thymocytes. These lymphocytes which attain maturation through the thymus are called the thymus-derived or thymus-dependent lymphocytes (T-lymphocytes).

In birds, the cloacal organ, the bursa of Fabricius, constitutes the second training centre. Humans, or mammals in general for that matter, lack this organ. Nonetheless, recent evidence shows that even among the

Fig. 1 Location of different lymphoid organs in an adult human



Beth is not a child from outer space. She is displaying a suit which gives mobility to immunodeficient babies who are otherwise condemned to stay in isolation in a sterile atmosphere. This suit, a space spin-off, has hoses for sterilised air. Note that the body is completely covered so that it does not come into contact with any contamination

mammals a functionally analogous organ does exist, which trains some of the lymphocytes in a way that they are both structurally and functionally different from the T-lymphocytes. It is now increasingly believed that the bone marrow itself serves as the equivalent of the avian bursa. The lymphocytes maturing through its influence are, therefore, known as the bone-marrow-derived or bone-marrow-dependent lymphocytes (B-lymphocytes). It will be evident later that this dichotomy in the nature of functionally mature lymphocytes is reflected in the two worlds of immune response (Fig.2).

The trained mature bodyguards are then grouped into well-organised units, which guard the crucial portals of entry all along the border (Fig.1). The entry of airborne pathogens through the nasal and oral passages is checked by the paratracheal lymph nodes which form a ring around the trachea and oesophagus. And the mesenteric lymph nodes studding the large intestine blocks the enemy which might enter through food and water. Some hostile pathogens which might sneak through the skin are prevented by a network of lymph nodes. These lymph nodes are all over the body, just under the skin, like the axillary lymph nodes under the armpit, the inguinal in the groin, and so forth. Besides these, there are the secondary units too, like the tonsils and Peyers' patches. All these distant, self-sufficient, scattered units are co-ordinated by the spleen which can perhaps be likened to a command centre.

Still, sometimes an enemy manages to evade the surveillance and enters the body. Such trespassers cannot be allowed to stage an insurgence. The roving patrol of the circulating lymphocytes moving freely about in all parts of the body takes care of them.

Every microbe, or for that matter any molecule, entering the body carries on its surface certain characteristic structural determinants, the antigens, which are unique to it. On reading this antigenic label, the lymphocytes decide whether the newcomer is a foreigner with malicious intent or a friend intent on building up the body's strength. No sooner an enemy is detected, the defence machinery is put into gear and the immune response is launched. The recognition of an invading antigen is in most cases carried out by the T-lymphocytes. Such antigens are known as the T-dependent antigens. Naturally, then, to mount an effective immune response against such antigens the integrity of the T-cells and the thymus is a prerequisite. However, there are a few exceptions, where the B-cells

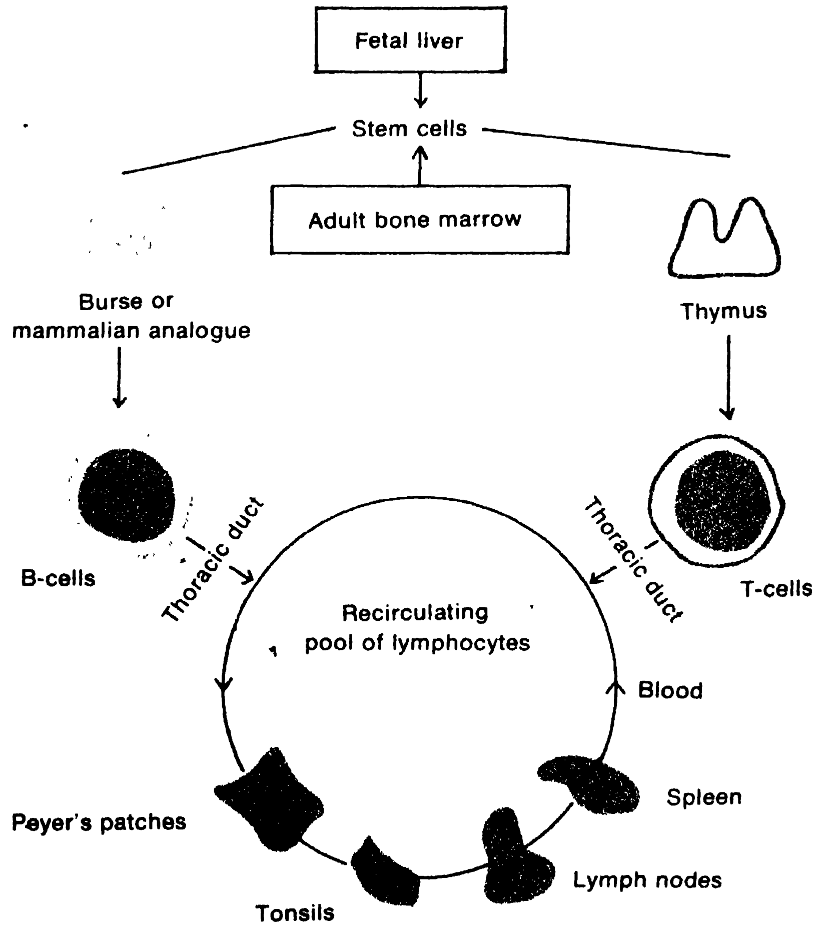


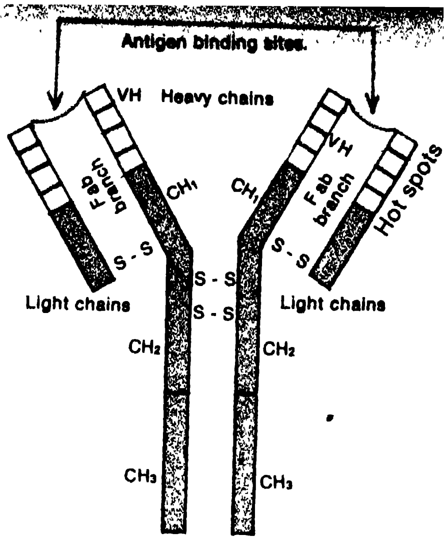
Fig.2 Developmental history of lymphocytes: Lymphocytes, cells responsible for immune reactions, develop from stem cells. Some stem cells migrate from the bone marrow to the thymus and finally become T-lymphocytes. Other stem cells develop into bone marrow-lymphocytes and become B-lymphocytes. On meeting specific antigen, T-cells are activated to produce cell-mediated immune responses and B-cells secrete antibody

The structure of immunoglobulins

THE general molecular structure of all the immunoglobulins is similar. These common features are exemplified by the structure of the IgG molecule. The molecule consists of two pairs of polypeptide chains. One pair, both members of which are identical, consists of about 214 amino acids in each of the chains, each of which has a molecular weight of 22,000. These are the light chains. The other pair constitutes the heavy chains. These have about 450 amino acids each, and a molecular weight of 55,000. The two heavy chains are linked together by a disulphide bridge and form the central core of the molecule. The light chains are also connected to this central area on the outside by disulphide bridges. The molecule thus assumes the conformation of the letter Y with a flexible hinge which enables the two arms of the molecule to swing through an angle of 90 degrees. The IgM molecule consists of five such units joined together.

In the human disease, multiple myeloma, one cell making one particular individual immunoglobulin divides over and over again in the same uncontrolled way as a cancer cell, regardless of the overall requirement of the host. The patient then produces the same immunoglobulin in enormously high concentrations. These immunoglobulins have lent themselves to analysis of the sequence of amino acids in their constituent chains. Such analysis has revealed that within a given major immunoglobulin class such as IgG, the N-terminal half of the chain shows considerable variation in the amino acid sequence, whereas the other half of the chain is relatively constant in this respect. The heavy chain also has a variable region located at the N-terminal end, and this is approximately of the same length as the variable half of the light chain. The remaining portion of the heavy chain can roughly be divided into three more or less identical parts of constant amino acid sequence. Each of these is as long as the corresponding region of the light chain.

Within the variable region, a number of amino acid positions in the peptide chains are substituted by a variety of amino acids and certain residues exhibit a notable hypervariability. The most attractive view, supported by the latest X-ray analysis, is that these "hot spots", three on the light chain and three on the heavy chain, lie relatively close to each other and form the antigen binding site. Their heterogeneity thus ensures diversity in combining specificities.



Structure of IgG An IgG-type antibody is a glycoprotein, containing two light and two heavy chains joined by disulphide bridges. Digestion of the IgG molecule with the protein-cleaving enzyme, papain, gives rise to three fragments an Fc fragment (the stem of the Y) and two identical Fab fragments (the prongs of the Y) IgG binds two antigen molecules through sites on its two Fab branches, and binds immune effector cells through its Fc stem. There are two types of antigenically distinct light chains known as kappa and lambda. Either of these might be present in an immunoglobulin molecule The type of the heavy chain, on the other hand, is specific to the class of immunoglobulin

alone bear the total responsibility for an immune response, including the initial process of recognition. These antigens are then known as the T-independent antigens.

The spleen, activated by the message received from the front-line defenders, mobilises fresh and massive specific recruitment. According to F.M. Burnet, all the lymphoid organs consist of several clones, each independently and specifically responsive to an antigenic determinant. The right clone then gets activated resulting in its rapid proliferation and a multifold increase in the number of properly armed lymphocytes. Then the defence forces engage in the battle royal of an active immune response.

The immune response is of two different types—the humoral and the cellular or cell-mediated immune response. The humoral response is characterised by the production of a particular type of globular proteins called collectively as immunoglobulins. To date five different classes of immunoglobulins have been discovered, namely immunoglobulin A or Ig A, Ig G, Ig M, Ig D, and Ig E. Of these, the Ig G and the Ig M are mostly involved in the reaction with the antigens. These immunoglobulins are highly specific and antagonistic to the invading antigen. The relationship between an antigen and the specific immunoglobulins generated in response to it can best be described as that between a lock and its key. These specific immunoglobulins are called antibodies and they act like the guided missiles. These guided missiles, with the tell-tale antigen on their surface, then hunt for the invaders.

B-lymphocytes differentiate into cells, producing specifically the antibodies. However, the blueprint for the specific antibody to be manufactured is provided by the T-cells involved in the initial recognition of the antigens. Thus, the synthesis of the antibody is manifest through a collaboration between the B- and T-lymphocytes. Selective depletion of one or the other type of lymphocytes by surgical processes or chemotherapeutic treatments have unequivocally resulted in almost total ablation of the humoral immune response. Reconstitution with the depleted lymphocyte type always leads to an immediate resurgence of the response.

The firm configuration consisting of an antigen and its specific antibody further activates a group of proteins in blood, collectively called complement. This complement is highly thermolabile and gets inactivated quickly at temperatures higher than 50° C. Even storage at room temperature for more than a few hours renders it inactive and hence functionally inert. The complement has been found to consist of nine different components which act in a sequential manner. The third component, known simply as C_3, has a specific affinity to an antigen-antibody complex and gets anchored on to such a complex. This triggers off a cascade of reactions. The end result of the complement activation is a multimolecular complex that can punch a hole in an invading microbial cell and cause its rupture.

The antibodies synthesised in the spleen or the lymph nodes are secreted, and let loose in the blood. They can easily be isolated from the straw-coloured cell-free fluid part of the blood, the serum.

There are also situations where the invader, instead of wandering freely via the blood stream, attacks a single organ and concentrates at one particular site. Here, it is the cell-mediated immune response which comes into play. Primary cancerous growth at any particular organ is such a situation. A newly grafted organ, although strictly speaking not a disease, is yet another instance of a concentration of foreigners at one site, since the antigenic passport it carries is of foreign origin. Here the *modus operandi* is different. The guided missiles of antibodies are kept in abeyance and in many cases they are not even manufactured. Instead, the tank brigade of activated effector cells is brought into action. These lymphocytes possessing characteristic antibody-like properties migrate to the site of the graft or foreign tissue and destroy it. This constitutes the cell-mediated immune response which is elicited by the effector or cytotoxic T-cells without any help from the B-cells.

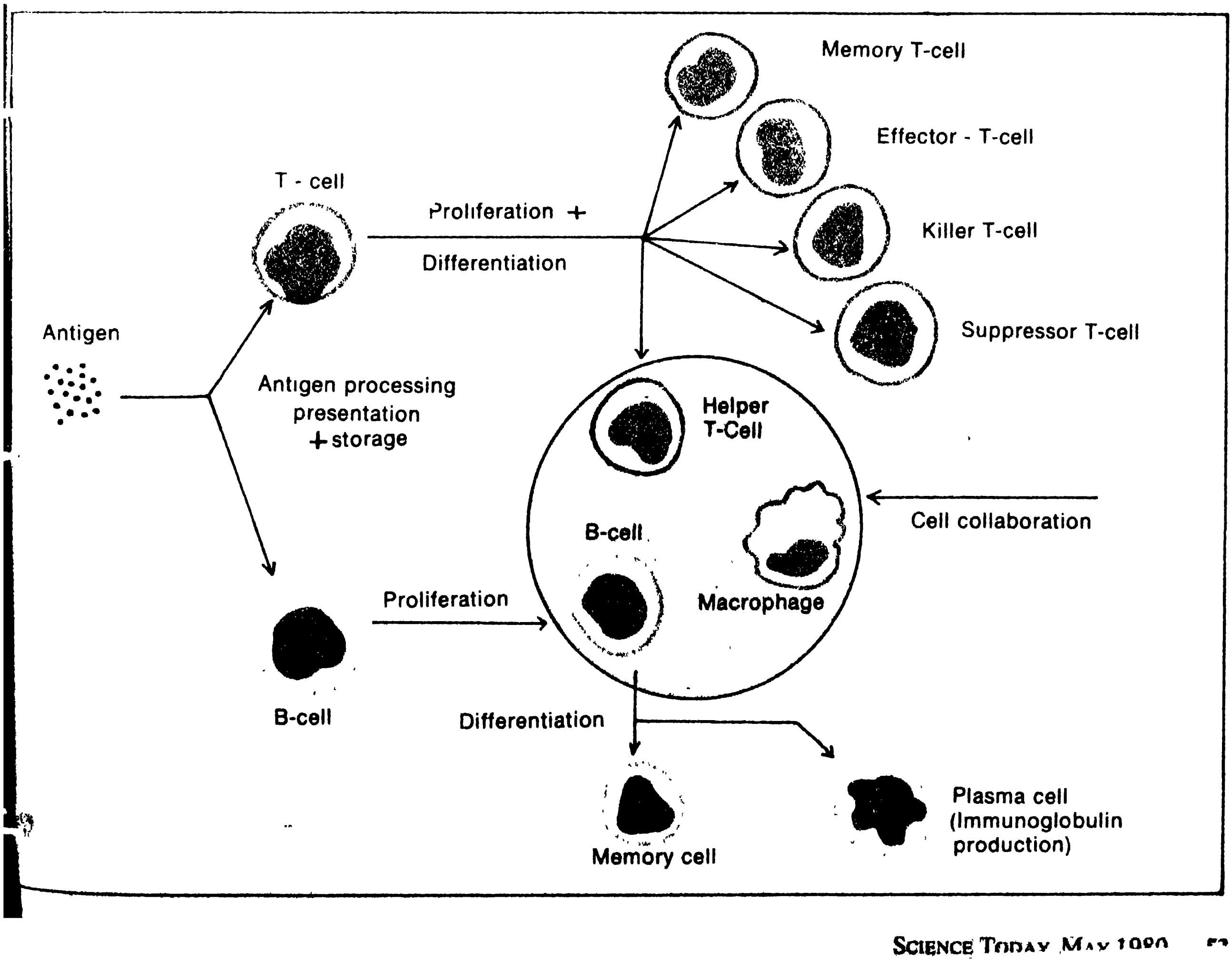
Evidence for the existence of a dichotomy in the lymphocytes originally obtained in birds was later provided in humans by R.A. Good. Bruton's agammaglobulinemia is a disease in which the afflicted are deficient in immunoglobulins and consequently unable to produce adequate amounts of antibodies and an effective humoral immune response. However, they have an intact cell-mediated immunity. Victims of the Di George's syndrome are beset with a reverse condition. When it was seen that these victims, mostly children, were congenitally devoid of thymus, the existence of T- and B-lymphocytes in man and mammals came to be firmly established.

The first definitive evidence suggesting heterogeneity among T-lymphocytes was derived from the studies of Harvey Cantor and his colleagues while dealing with a specific type of cell-mediated immune response called the graft-versus-host reaction. They observed a synergy between lymphocytes from the spleen and the peripheral blood lymphocytes. Later, other populations of lymphocytes were found to synergise similarly. Furthermore, it was shown that both the populations required for the synergy were thymus-derived. As of today several such sub-sets are known, for example, there are the T-cells which get activated in response to an antigen and kill the invading microbial cells; these are the cytotoxic or killer T-cells. In contrast, the effector T-cells are responsible for the manifestation of cell-mediated immune response like delayed hypersensitivity and which are also activated specifically by an antigen but are not cytotoxic. Also, an efficient humoral immune response against most of the antigens can be generated only through a collaboration between T- and B-cells. Obviously, then, there must be a population of T-cells which help the B-cells by triggering the latter into synthesising a specific antibody. These are called helper T-cells. Such helper cells have now been found even in the expression of cell-mediated immune responses which are totally a T-cell phenomenon. Suppressor T-cells, yet another sub-set of T-cells, bring about suppression of immune response instead of its augmentation.

Even the B-cells exhibit heterogeneity. For, the B-cells, which along with the T-cells, are involved, albeit indirectly, in the process of recognising an antigen are not the same as those which in the end synthesise the specific antibody. If at all, the latter is a distant progeny of the former. The stage, therefore, is crowded with several sub-populations with an intricate interplay among them responsible for the regulation of the immune response (Fig. 3).

Macrophages, yet another type of cell, also play an important although indirect role in eliciting both types of immune response. They also originate in the bone marrow, and their developmental lineage is parallel to that of lymphocytes. The mononuclear phagocytes are produced by rapidly dividing precursor cells in the bone marrow. The daughter cells called monocytes are released in the blood stream where

Fig 3 Present concepts of cellular events in immune response



they circulate for a while but soon leave it to settle down in solid tissues. Here they get differentiated into the various types of macrophages. They often survive in the tissues, mainly in the liver, spleen, lungs and peritoneum, for many months or even years.

Macrophages are rich in hydrolytic enzymes and consequently are extremely efficient in the ingestion and digestion of pathogens and abnormal cells. Their phagocytic action is particularly swift whenever an antibody-antigen complex is formed. Besides their ability to produce interferon, they are also involved in amplification of weak antigens and their subsequent presentation to the T-cell. They also bring about pairing of the proper T- and B-cells for their collaborative endeavour. Under suitable conditions, macrophages can be transformed into activated macrophages with enhanced hydrolytic enzyme activity and hence increased phagocytic capacity. This activation can be induced by a variety of agents including bacterial endotoxins, double-stranded RNA as well as factors derived from activated T-lymphocytes. Also, whenever the antigenic label on the foreign graft or an abnormal cell is weak like in the case of many tumours, the T-lymphocytes are not sufficiently alerted and cannot eliminate the tumour cells. However, the latter can be achieved by an amplification process involving co-operation between the T-cells and the macrophages.

A unique aspect of the immune response is its memory. On the first encounter with an antigen, a primary immune response is launched. This is relatively slow as reflected in a rather long latent period (lag) with no measurable antibodies in circulation. This lag period, in most cases, would be between one and four days on the first encounter with the antigen. During the next, logarithmic phase, the production of antibody exceeds catabolism. Then the level of serum antibody increases in geometric progression, reaching a high value (plateau) in a short span of time. This high level is maintained for some time, though the extent of plateau phase varies widely, depending on the degree of persistence of the individual antigens. This explains the long-lasting immunity conferred by persisting virus, following certain viral infections like small-pox and scarlet fever. Certain bacterial antigens like pneumococcal polysaccharides are known to persist in man for 20 years. Such is not the case with all immunogens. Most humoral responses wane with time, as the catabolism far exceeds active antibody production.

Although, finally, the quantity of antibody (titre) wanes, the memory of the first encounter is left behind in the

lible impression of the antigen. When the same antigen ventures to re-enter, its recognition is speedy with a swift

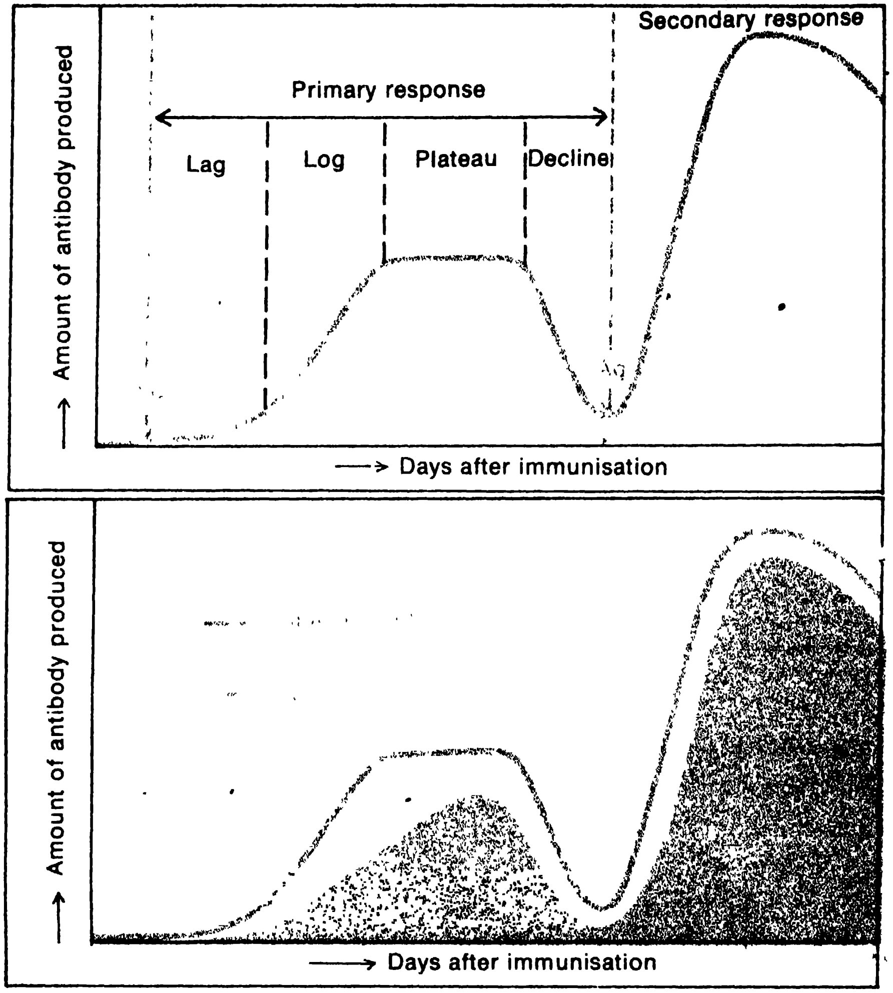


Fig 4a and 4b Graphical representation of antibody production eliciting primary and secondary responses. When an immunogen (antigen) is introduced, antibody production follows a characteristic pattern consisting of (1) the lag phase, (2) the logarithmic phase, (3) the plateau, and (4) the phase of decline. A quicker and more vigorous immune response is observed when the same antigen is encountered a second time—bringing about the secondary response

Vaccines

VACCINES fall into three general categories, which differ only in the mode of introducing the infectious organism in the body without bringing disease to it. The simplest to understand is the class exemplified by the Salk vaccine against poliomyelitis. This is made up of the virus particles killed with formalin. A dead virus obviously cannot grow to colonise and infect the host. However, care has to be taken to ensure that the antigenic structure or composition of the virus is not significantly altered in the killing process. The killing can also be effected by heat or radiation. Other vaccines of this category are those against typhoid, paratyphoid, cholera and some forms of whooping cough.

There are some bacterial pathogens like diphtheria or tetanus which manifest their pathological effect through the toxins they exude. Such toxins can be detoxified chemically, without destroying their major immunogenic components. Immunisation with such chemically altered toxins, called toxoids, forms the second category of vaccines. It provokes the formation of protective antibodies.

The most powerful vaccine, which is termed as the live attenuated vaccine, belongs to the third category. Living bacteria or virus particles which can actually infect and multiply in the host constitute these vaccines. However, either natural microbes deprived of their pathogenicity or genetic variants lacking the virulence of the original strain are used. The cowpox virus used by Edward Jenner is an excellent example of such a vaccine. So is the BCG (Bacillus Calmette Guerin) vaccine. These live organisms are identical to the disease-causing microbes in their antigenic profile, but do not possess their and massive manufacture of the specific antibody. This constitutes the secondary immune response (Figs. 4a and 4 b). Like the immune response itself, immunological memory is also specific. If the primary response was initiated by an antigen A, memory to A only is registered. Consequently, if two different antigens, A and B are presented later, secondary response is generated only to antigen A; B elicits only a primary response. This remarkable property of immunological memory forms the basis of the programme of immunisation or vaccination. Vaccines are modified pathogenic agents which retain the antigenic characteristics of the infectious organism without its ability to cause disease. Injection of a vaccine is followed by the onset of a primary response but, more significantly, by the build-up of memory cells. When the live virulent pathogen attacks subsequently, it is dealt with by a rapid secondary response of great magnitude.

The body's sentinels at times get overenthusiastic. Their actions, however well-intended, bring discomfort to the body instead of providing relief. This results in allergic disorders which are rightly termed as hypersensitivities. At other times, the bodyguards turn outright rebellious. They lose their sense of propriety and abandon the principle of self and non-self. They stop distinguishing between friend and foe and start attacking the very body it is their vocation to defend, leading to the onset of autoimmune diseases. Suppression of these weird immunological reactions is called for and is practised. But this can occasionally be too drastic a remedy. Another approach would be to rekindle their ability to distinguish the self from the non-self.

Among the most important discoveries to be made in immunology are those that relate to the recognition of 'self' and the role of the thymus. In the early 1950's Sir Peter Medawar and his colleagues established the body's ability to distinguish self from non-self. Their experiments were stimulated because of the difficulties encountered by surgeons when they tried to graft other people's skin onto badly mauled wartime pilots. These experiments led to the discovery of the transplantation antigens, known as HL-A in humans and H-2 in mice, which are genetically determined 'self' markers on the cell surface that cause transplant rejection.

The thymus teaches the T-cells what to recognise as self and what to reject as non-self, though it was not known till recently, why this recognition is necessary. The discovery of so-called H-2 restriction provided an important clue to this question. T-cells will not co-operate with B-cells to produce antibody, nor will they kill the infected cells on their own, unless the B-cell or the infected cell carries the self H-2 markers. Hence, the self antigens play an important role in the immune interactions of T-cells. This also implies that T-cells can recognise both their own self antigens and the antigen on an infected cell. But whether they do that with two receptors, one for the viral and one for the H-2 antigen, or with just one receptor is not yet known.

Michael Bevan at the Massachusetts Institute of Technology, USA, and Rolf Zinkernagel and his colleagues at Scripps Clinic and Research Foundation, USA, Jan Klein at the Southwestern Medical School, Dallas, USA, and Günther Dennert at the Salk Institute, USA (*Nature*, **271** 251), have all unequivocally established that it is where the T-cell matures that determines what it sees as self. In other words, the determination takes place in the thymus.

Now immunologists will try to find out what goes on in the thymus during this critical process. But there is still one practical implication of this study: thymus transplants will not work, since the transplanted thymus would programme their T-cells to defend only the thymus and not the person.

Immunological tolerance is yet another characteristic feature of the immune system. Studies of this phenomenon has shed some light on the very fundamental question, "How does an antigen get recognised?"

Some significant information in this regard has emerged from studies of cell-mediated immune responses of the type that result in the immune rejection of skin or organ transplants. Grafts between identical twins are not rejected but those between less related people are. The antigens on the surface of the cells constituting the grafted organ which arouse suspicion of the lymphocytes of the recipient inciting him to mount a cell-mediated type of immune response are called the histocompatibility antigens. In humans, these are known as the HLA. These HLA are products of genes called the HLA genes or the major histocompatibility complex (MHC) genes, which lie clustered on chromosome 6 but their precise position is still uncertain. These HLA genes are distinct from the genes whose products are the specific antibodies. It has been proved that the dichotomy of the immune response was ingrained deep in its hierarchy and existed even at the genetic level.

The extreme polymorphism of the histocompatibility antigens made immunologists wonder whether the

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ability to cause disease. The advantage of such a vaccine is that it stimulates a natural infection. The organism multiplies to some extent within the body and thus magnifies the antigenic stimulus.

In general, live or attenuated vaccines induce a more effective and longer period of immunity than do the killed or inactivated forms of vaccines. This is because the replication of the living microbes confronts the host with a larger and more sustained dose of the antigen. Also, better protection is afforded because the immune response takes place largely at the site of the natural infection. For example, oral cholera infection will be most efficiently dealt with by antibodies produced locally by the gut wall. Yet, injecting killed vaccine may stimulate antibody synthesis in the spleen and perhaps in many lymph nodes without initiating an adequate response in the intestinal lymphoid system. Ideally, immunity would be best established by infection with a live but attenuated form of cholera bacillus which would multiply at the site of natural infection without producing the disease.

To date, vaccines to prevent some 20 infections are available. The diseases are small-pox, cholera, rabies, typhoid, paratyphoid, whooping cough, diphtheria, tetanus, polio, tuberculosis, typhus, mumps, measles, German measles, yellow fever, scarlet fever and even the Japanese encephalitis. Despite this impressive list, there are still several other common infectious diseases against which effective vaccines remain to be prepared. These include pneumococcal pneumonia, hepatitis (jaundice), leprosy, malaria, venereal diseases, and even the highly familiar influenza. One of the principal difficulties in developing these vaccines is the inability to obtain adequate numbers of the causative organisms. The organisms cannot be isolated easily and grown in culture for one of two reasons. Some, being viruses, are obligate parasites (as in the case of hepatitis), others have a peculiar life cycle which precludes their growth *in vitro* (as in malaria).

Notwithstanding these hurdles, scientists are drawing upon advances in virology, bacteriology, chemistry and genetics to expand the spread of vaccines. They are making vaccines from parts of the infectious agents rather than the whole agent. They are exploring the value of giving benign organisms to enhance the efficacy of a vaccine. They are trying to use the recombinant DNA technique to alter genetically the pathogen so as to prepare an attenuated vaccine (SCIENCE TODAY, April 1980, p. 7). Some scientists are even toying with the idea of making a totally synthetic vaccine.

Arthritis cure in [illegible]n

ARTHRITIS has many forms but the most painful and devastating one is rheumatoid arthritis. It is characterised by excruciatingly painful joint inflammations and in certain cases even death occurs. Recently, it has been suggested that it is an auto-immune disease where the antibodies mistakenly attack the body's own tissues.

Marine Teodorescu and his coworkers from the University of Illinois Medical Center, Chicago, USA, discovered that immune cells from rabbits produce an activator that in turn stimulates B-cells to make auto-antibodies. Based on this discovery, researchers put forward a hypothesis that this activator is not produced in healthy rabbits and healthy human beings and thus auto-antibodies are not produced. But in the case of rheumatoid patients, such a restraint is missing and the activator is therefore able to create auto-immune disease. This hypothesis was further tested by examining the blood of 21 rheumatoid patients for the presence of the activator. Sure enough, 19 of them indicated the presence of the activator and all of them had active disease. Hence, the activator might be the factor responsible for the production of rheumatoid arthritis.

Efforts are now on to determine the chemistry of the activator. After that, attempts will be made to find some way to thwart its auto-immune abilities and in turn the rheumatoid process. Without doubt, success of this work would be a magnificent victory against one of the most common chronic diseases, especially in old people, for which there is currently no cure.

A route of antigen transfer

THE transmission of maternal immunoglobulins across foetal and neonatal tissues is essential for the survival of mammalian newborns. This way the developing mammals passively acquire immunity until their own immune system develops. In the baby rat, maternal immunoglobulins occurring in the milk are transported across the proximal small intestine during the first three weeks after birth. This transport process is highly selective for immunoglobulin G (IgG). The other immunoglobulin classes are transferred in much smaller amounts or not at all. Instead, they are digested intracellularly by absorptive cells in the distal parts of the intestine.

Potential antigens of the mothers are also transferred to the infants in some instances. This can lead to the suppression or enhancement of the immune response. Alternatively, if the antigen is a pathogen, active infection may occur in the young. However, the mechanisms of transfer of antigen from the mother to the young were poorly understood till recently.

At the University of Virginia this transfer process was found to occur in the form of antigen-antibody complexes across the proximal portion of the small intestine of the suckling rat. Three possibilities are put forward for the actual mechanism of absorption of immune complexes. The antigen in the complex may: (i) dissociate and possibly infect the newborn; (ii) suppress or enhance an active immune response; or (iii) induce tolerance. Any one of these three alternatives might occur. Hence, it appears certain that the transfer of the antigen affects the well-being of the newborn.

Of guests and intruders

THERE are two situations in which the immunological surveillance of the body is successfully evaded by the "foreigners". One of these is a welcome guest, the other a dreaded intruder. The embryo or growing foetus, however wanted and desired, is still, immunologically, a stranger. So is the unwanted and hated cancer. It is now known that embryos and cancers share several characteristics.

At least three tumour antigens are apparently specified by genes that are normally expressed at the early development of the organism. These "foetal" antigens are :

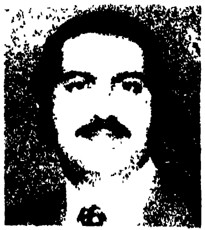
Carcinoembryonic antigen (CEA) is usually found in cancers of the digestive system, especially the colon. It is also found to be present in gut, liver and pancreas of human foetuses between the second and sixth months of pregnancy. A highly sensitive radioimmunoassay can detect extremely low levels of CEA in blood and this can be used as an early diagnosis measure.

Alpha foetoprotein (AFP), appears in the blood of pregnant women and patients with cancer of liver. Embryo serum also contains it in significant amounts. In mice, antibodies to AFP have been found to suppress tumours which secrete AFP.

Gamma foetoprotein: In contrast to CEA and AFP, this occurs in a wide variety of human tumours, both malignant and benign. It is readily demonstrable in foetal serum but not in adult serum. Because of its widespread occurrence, it is being looked upon as a highly promising diagnostic tool.

Apart from these similarities in their antigenic make-up, a recent report from Britain suggests that the different camouflage adopted to fool the immune system is also common. It is seen that the embryonic antigens are coated with a protein called transferrin which prevents its rejection by the immunological mechanism. Such coating is also found in some tumour cells.

function of these antigens was restricted to the graft rejection phenomenon. Would they have a more substantive role to play? It now appears that these antigens, at least the MHC, are involved in the recognition of antigen by the T-cells and the regulation of immune response of both types. The experimental evidence amassed so far has led to the formulation of two alternative concepts. One concept, postulated by R. Zinkernagel and his associates, is known in immunological jargon as the "altered self" hypothesis. According to this, the invading virus or a chemical antigen modifies the self MHC antigens, forming a complex new antigenic determinant involving the self antigen as well as the foreign antigen. The killer T-lymphocytes are programmed to recognise this altered self MHC antigen through a single receptor. The other proposal called the "dual recognition" hypothesis was put forth originally by D.H. Katz and B. Benacerraf to explain the collaboration between T- and B-cells. Subsequently, the experimental evidence obtained by P. Matzingar, M. Bevan and P.C. Doherty and his colleagues has favoured this scheme which envisages the killer cells recognising both the unmodified self MHC as well as the foreign non-MHC antigens through two independent recognition sites. "Altered self" or "dual recognition"? The question is still unresolved and hotly debated.

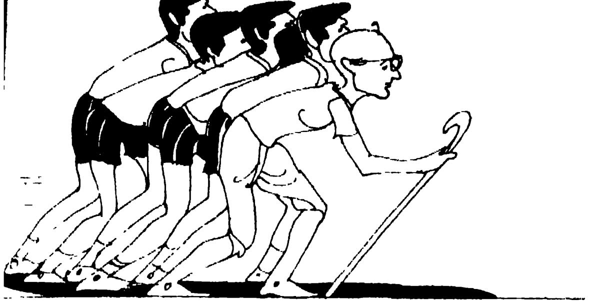


Dr. Phondke. Head Radiation Biology and Occupational Health Section, Medical Division, Bhabha Atomic Research Centre, Bombay, is actively associated with research in different areas of immunology, cancer biology and biophysics. He is a Fellow of Maharashtra Academy of Science. His other interests include writing science fiction, short plays and popular articles in Marathi.

Further reading :

1 Burnet, F.M. 1959: *Clonal selection theory of acquired immunity,* Cambridge University Press, London. 2. Good, R.A. and Varce, R.L. 1955: A clinical and experimental study of agammaglobulinemia, *Lancet,* 73, 245. 3. Cantor, H. and Boyse, E.A. 1977: Regulation of cellular and humoral responses by T-cell sub classes, *Proceedings of the Cold Spring Harbour Symposium,* 41, 23. 4. Tiselitus, A. and Kabat, E.A. 1939: Electrophoretic characterisation of serum protein possessing antibody activity, *J. Exp. Med.,* 69, 119. 5. Burnet, F.M. 1969: *Self and non-self,* Cambridge University Press, London. 6. Nossal, G.J.V. 1969 *Antibodies and Immunity,* Basir Books Inc., New York. 7. Roitt, I.M. 1976: *Essential Immunology,* Blackwell Publications. 8. Golub, E.S. 1977: *The cellular basis of immune response,* Sinauer Associates Inc., Sunderland, Massachusetts.

low much do you know about IEALTH and DISEASE?



Vhich are the basic human blood groups? A, B, AB, and O. Correct. Now, where is your liver, on the left side or the right side of your body? Don't know? We are not surprised. Knowledge of medicine can help you take a number of decisions—vhat to have for a snack, whether or not to keep a pet, whether it is all right to marry your cousin, and a lot more. This month's quiz is intended to help you learn a few everyday facts that concern your health. Choose the alternative(s) you think correct for each question. After that, turn the page for the correct answers.

1. If a stray dog bites you, you should A. wash the wound with soap and water immediately. B. cover the wound with gauze. C. suck the wound to remove the poison.

2. Match the diseases (I, II, III, and IV) with the relevant comments (A, B, C, and D): I. Rabies, II. Jaundice, III. Measles, IV. Chicken pox. A. Its infective version is usually caused by polluted drinking water. B. Antibiotic therapy is used in these cases to prevent scarring caused by secondary infection. C. Onset is invariably followed by death. D. Can be quite dangerous to children, but is preventable by vaccination.

3. The difference between a vaccine and a serum is that A. vaccines give only short-term immunity as compared to serums. B. vaccines are more likely to cause allergic reactions. C. serums contain living or dead microorganisms. D. vaccines bring about active antibody production providing immunity for longer periods.

4. Frequent bouts of an untreated disease, in children, is known to cause heart trouble in some cases. The disease associated with this problem is A. influenza, caused by a virus. B. rheumatic fever, usually involving a throat infection. C. encephalitis. D. measles.

5. Convulsions are dangerous in young children because A. they are a symptom of dangerous diseases. B. they are caused by uncontrolled rise in temperature which can cause death in some cases. C. they denote heart trouble. D. they are connected with epilepsy.

6. Young children die after a severe attack of diarrhoea usually due to A. dehydration. B. perforation of the small intestine. C. liver damage.

7. You are more likely to suffer from a heart attack if you already suffer from A. diabetes. B. anaemia. C. amoebic dysentry

8. Cirrhosis of the liver is caused by A. infections. B. alcohol. C. drugs.

9. All the following diseases can at present be prevented by immunisation except A. Japanese encephalitis. B. measles. C. smallpox. D. malaria.

10. Of the diseases mentioned, which are the two greatest killers in India? A. Tuberculosis. B. Leukaemia. C. Pneumonia. D. Diarrhoea.

11. For the mentally ill, the best hope today is A. modern psychoanalysis. B. drugs. C. electro-convulsive therapy. D. neurosurgery.

12. Susceptibility to certain diseases are passed on from parent to child. Which of the following diseases can you identify as hereditary? A. Diabetes. B. Muscular dystrophy. C. Polio. D. Tuberculosis.

13. The danger to children caused by Rh incompatibility between parents can be reduced by A. giving the mother immunoglobulin. B. giving the mother blood transfusions. C. avoiding marriages between persons of the same Rh group.

14. Which of the following can be dangerous to the developing child in early pregnancy? A. X-rays. B. Sedatives given to the mother. C. Mother getting measles.

15. Which of the following is known to be carcinogenic (cancer-causing)? A. Coal-tar dyes, sometimes sold as food colours. B. Hair dyes. C. Saccharine. D. Cyclamate.

16. An overdose of some vitamins (A and D) is more dangerous than others (B and C) because A. they settle down in the liver. B. they are quickly metabolised. C. they dissolve in fats rather than water and tend to accumulate in the body. D. they disturb digestion.

17. In certain parts of India, especially Madhya Pradesh, paralysis and deformity of the body result from the consumption of A. *moong dal.* B. *masur dal.* C. *khesari dal.*

18. To put on weight, which of the following fruits would you choose to eat? A. Bananas. B. Oranges. C. Apples.

19. One feels discomfort in an overcrowded room due to A. physical changes in the air. B. chemical changes in the air. C. biological changes in the air.

20. There is a population explosion in India because A. both birth rate and death rate are equally high. B. there is a wide gap between birth rate and death rate. C. there are more women than men in India.

Awards & Appointments

Jawaharlal Nehru awards

THE INDIAN Council of Agricultural Research (ICAR) has named five agricultural scientists for the Jawaharlal Nehru award for outstanding postgraduate research work for 1979-80.

The winners are Dr. Baljit Singh and Dr. Manjit Mahal, both of Punjab Agricultural University, Ludhiana; Dr. P. [illegible]n of the Central Rice Research Institute, Cuttack, Dr. Hari Shankar of the Indian Veterinary Research Institute, Izatnagar, and Dr. K.P. Joy, a fisheries researcher.

Each award carries Rs.5,000 in cash and a citation.

FICCI awards

The Federation of Indian Chambers of Commerce and Industry (FICCI) has announced its 1979 awards for outstanding contributions by individuals, companies and institutions to various fields of socio-economic development.

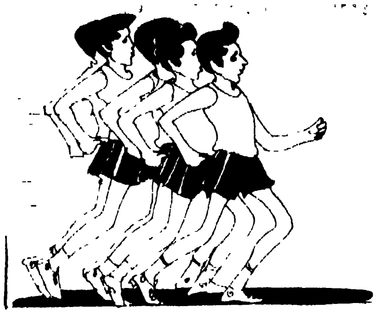
Among these, the award for research in science and technology has been shared by the Central Electronics Engineering Research Institute, Pilani, and the National Aeronautical Laboratory, Bangalore.

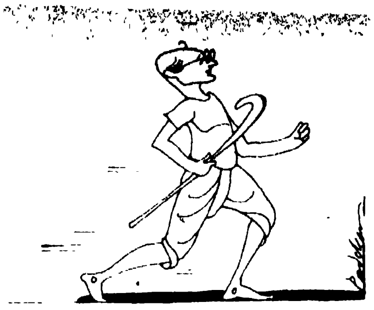
In addition, three cash awards of Rs.10,000 each have been shared by the following scientists:

Dr. P.M. Bhargava, Head, Centre for Cellular and Molecular Biology, Hyderabad, and Prof. Arun Kumar Sharma of Calcutta University share the award for the life sciences.

The award for physical sciences has been shared by Prof. S Chandrashekhar of the Raman Research Institute, Bangalore and Prof. N Rudraiah of Central College, Bangalore.

The award for 'technology with particular reference to its interaction with industry' has also been shared by Dr. L.K. Doraiswamy, Director, National Chemical Laboratory, Pune, and Dr. P.K. Patwardhan, Computer Section, Bhabha Atomic Research Centre, Bombay.





The Answers

1. — A: The dog could be suffering from rabies, in which case its saliva will contain the fatal viruses. The saliva left on the wound has, therefore, to be washed away as quickly as possible. If soap is not available, flushing with plain water is sufficient. Never suck the wound to remove poison.

Pets may be cute They can also be deadly

2. — I-C: Chances of survival are negligible, if rabies is not prevented with a timely course of vaccination.

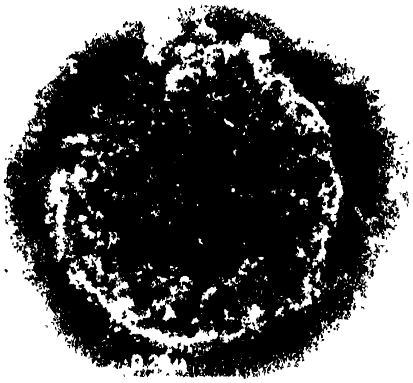
II-A: Polluted drinking water can cause infective hepatitis with the symptoms of jaundice.

III-D: Measles is worth preventing. Measles vaccine is getting popular with doctors treating children.

IV-B: Chicken pox is caused by a virus, but later bacteria can cause secondary infection which can leave bad scars. Antibiotics can prevent this.

3. — D: Serums give short-term benefits, while vaccines provide immunity for longer periods. It is the serums that cause allergic reactions frequently. A good example of a serum is the ATS (anti-tetanus serum) given in case of some injuries to obtain immediate protection against tetanus.

4. — B: Rheumatic fever. Measles cannot cause frequent bouts because one attack usually creates enough immunity to make a relapse unlikely.



Electron micrograph of a single human measles virus

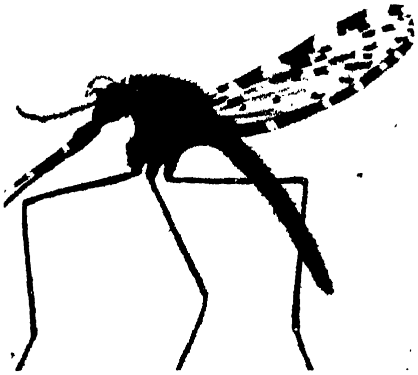
5. — B: Timely attention to a child's fever can prevent many unexpected infantile deaths. Doctors usually prescribe children's aspirin or a fever-reducing (antipyretic) syrup, usually containing paracetamol. The brain's temperature controlling centre can go out of action if fever goes beyond 39.5°C.

6. — A: When a child suffers from diarrhoea, there is extreme fluid loss from the body. When this deficit exceeds five per cent of the body-weight, there is increased heart rate, irritability, passing little or no urine, etc. When the deficit reaches 10 per cent of the body-weight, the child may become unconscious. Greater deficit causes death.

7. — A: Diabetics are particularly prone to suffer from heart and vascular diseases. A London study has shown that approximately 20 per cent of all diabetics die of heart attacks. This includes women (in whom heart attacks are not as common as with men).

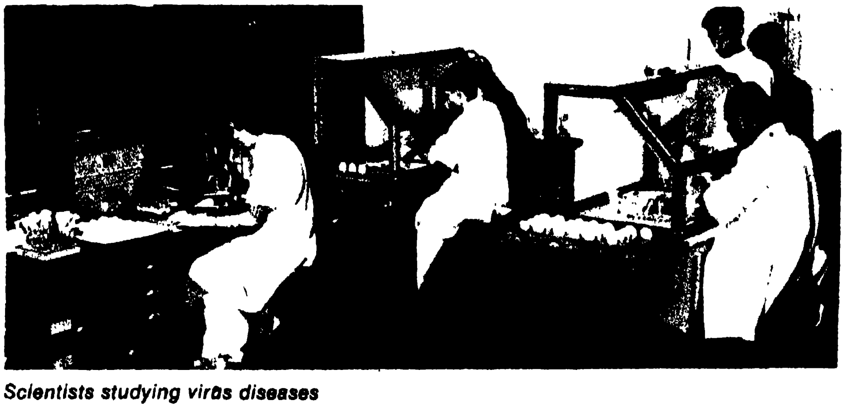
8. A, B and C: All these are capable of damaging the liver causing necrosis (death of cells) and scarring. The drugs especially incriminated are trichloroethylene, methotrexate, methyl dopa and oxyphenacetin. Carbon tetrachloride, chloroform, arsenic and phosphorus are also harmful to the liver. Of the liver infections, viral hepatitis is the most common.

9. — D: Immunising agents against malaria are being developed for the preparation of human vaccines against the disease. But these are at present only in experimental stages.



Malaria-causing anopheles mosquito

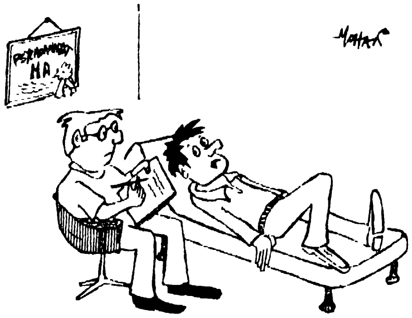
10. — A & D: Tuberculosis and intestinal infections (mainly diarrhoea and dysentry) are big killers. Practically 10 per cent of all deaths due to disease in India are caused by TB. Supply of clean drinking water in adequate quantities could be the best solution to prevent diarrhoea.



Scientists studying virus diseases

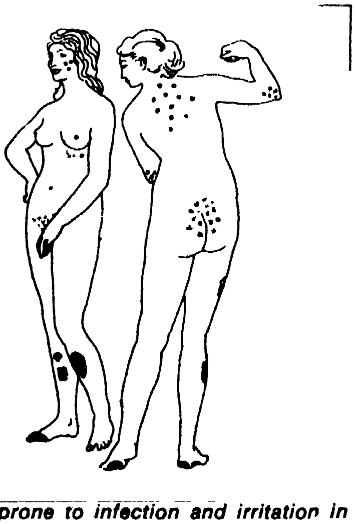
Sputum test for tuberculosis

[illegible] class of drugs known as phenothiazine derivatives have revolutionised psychiatry over the last 20 years. Chlorpromazine is a widely used drug of this class. The credibility of psychoanalysis has steadily declined in recent times. Neurosurgery, except in a handful of cases, has little importance in curing mental illness, but future research may change this.



"I'll admit something—I too am a psychoanalyst!"

12. — A & B: Diabetes and muscular dystrophy are genetically transmitted. TB and polio are, however, not inheritable. Polluted drinking water causes polio, and a TB patient can spread his infection to his child as well as to his neighbour's child. The danger of a child inheriting a disease is highest when both his parents have the same (inheritable) disease. Chances are greatest when closely related people marry each other. So, a person with any inheritable disease, or with a history of such disease in the family, should consult a medical specialist before planning marriage.



Areas prone to infection and irritation in diabetics

13. — A: Rh incompatibility problems are best avoided by giving the mother immunoglobulin injections at the time of the first childbirth. The problems arise usually on account of the child's Rh mixing (inside the mother's body) with the mother's Rh blood. The first child is often unaffected, but the mother develops antibodies in her blood which usually harms subsequent Immunoglobulin suppresses the formation of antibodies.

When a child develops trouble, indicated by a form of jaundice, it is the child that needs immediate and frequent blood transfusions, not the mother.

14. — A, B and C: The first trimester (three months) of pregnancy is critical for the developing fetus. During this period, doctors try to avoid drugs and minimise the quantity of chemicals to which a pregnant mother is exposed. A sedative drug—thalidomide—unsuspectingly given to mothers during this critical period caused hundreds of children to be born with defects such as missing limbs. Prolonged exposure to X-rays and German measles in expectant mothers can also cause serious harm to the fetus.

'Thalidomide child' uses an artificial limb

15. — A, B, C and D: Saccharin is safe in small quantities for those who use it on medical advice. But it is dangerous to public health when used in items like soft drinks and ice creams by unscrupulous manufacturers who wish to save money on sugar.

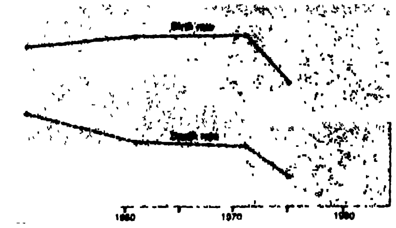
16. — C: Self-prescribed vitamin tonics can do more harm than good. So the next time you think you need a tonic, try a milk shake instead. It may do more good at the same cost (unless of course you are overweight).

17. — C: The seeds of *khesari dal* contain a toxin called beta oxalyl amino alanine which affects the nervous system causing paralysis of the lower limbs. Studies have shown that paralysis will result if diets containing 30 to 40 per cent of this *dal* is eaten over a period of two to six months. Since this *dal* is cheap, the disease is prevalent amongst landless agricultural labourers who often receive it from their employers in lieu of wages.

18. — A: In proportion to its weight, bananas yield more calories than either apples or oranges. One banana yields 116 calories as compared to 59 from an apple and 48 from an orange.

19. — A: For a long time it was believed that the feeling of discomfort experienced in an overcrowded, ill-ventilated room resulted from decreased oxygen and increased carbon dioxide in the atmosphere. This has now been refuted. Studies have shown that even where the oxygen content is reduced to 18 per cent and the carbon dioxide content raised to 5 per cent, no ill effects occur provided the temperature and humidity are at satisfactory levels. Air movement and heat radiation are other physical factors that influence comfort.

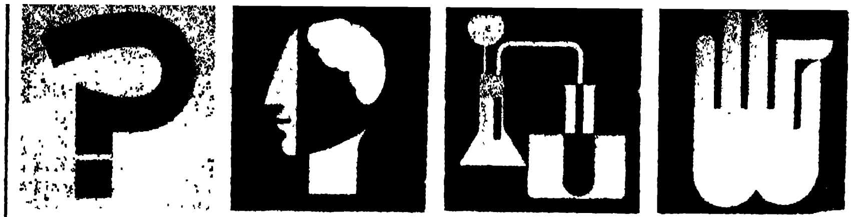
20. — B: There is a wide gap between the birth and death rates. Seventy years ago, there was no population problem in India. At the time, both birth and death rates remained high (b.r. 48.1 and d.r. 47.2) keeping the population stationary. Gradually, over the years, the birth rate fell, but only marginally. The death rate fell more steeply (in 1975, b.r. was 32.5 and the d.r. 15.9). The population has therefore risen alarmingly.



Mean birth and death rates in India

This quiz was prepared by Dr. SAROJ S. JHA and Dr. S. RAMANI

Some affected natives of Madhya Pradesh



21 landmarks in

The method of science

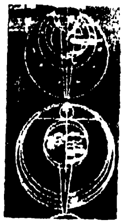
5

What is presented here is not a display of landmarks in the history of science but landmarks in the history of the method of science.

1. *Roger Bacon*

1220?-1292?

Recognition of the importance of experiments and of direct observation laying the foundations of the method of science



Eye s refractive media from Roger Bacon *Opus Major*

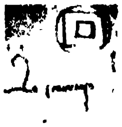
2. *Leonardo da Vinci*

1452-1519

First major contribution of science to the beginning of a "new age" the Renaissance in Europe

From Leonardo s notebook

Leonardo s signature in reverse - ' I Leonardo



Self-portrait 1512

3. *Nicolaus Copernicus*

1473-1543

First major scientific discovery ("the earth revolves round the sun") that eventually toppled a widely held non-scientific belief ("the sun revolves round the earth")

6. *Rene Descartes*

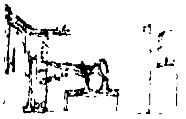
1596-1650

Introduction of the rigid concepts of mathematics and logic, and of the method of doubt and questioning, into the method of science.

7. *Isaac Newton*

1643-1727

First application of the experimental method—the method of science—for arriving at a set of interrelated generalisations



Newton s drawing of his prism experiment

8. *Founding of the Royal Society in Britain* (1662) and *Academic Royale des Science in France* (1666)

Availability for the first time of organisational support to the idea of conducting experiments.

Frontpiece of *History of the Royal Society*, 1667 Lord Brouncker the first president (left), Charles II its patron (centre) and Francis Bacon (right)

Louis XIV inspecting his Academic Royale

12 *Louis Pasteur*

1822-1895

Demonstration that living organisms can be generated only from similar living organisms laying of the foundation of modern biology. Recognition of the role of bacteria in spoilage, for example, of food and in disease.

Pasteur in his Paris laboratory and his study of silkworms (right)

13 *Karl Marx* (1818-1883) and *Friedrich Engels* (1820-1895)

First application of the method of science to the study of human history and to an integrated analysis of social, political and economic problems This analysis led to the formulation of the first science-based socio-politico-economic theory

Cover of the first German edition of *Capital* Vol I, 1887

Das Kapital

Kritik der politischen Oekonomie

17 *John Desmond Bernal*

1901-1972

First statement of the intimate relationship between science and society

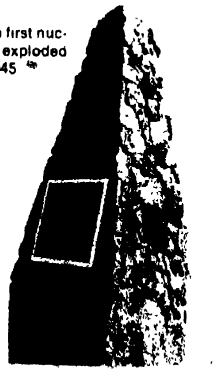
18 *P M.S. Blackett* (1897-1973) and *J.D. Bernal* (1901-1972)

First highly successful application of the method of science to the conduct of major operation in a war (World War II) Operational research—destined to play a vital role in social development—comes of age Blackett and Bernal successfully worked out the ways and means of combating the U-boat (the German submarine) menace during the war.

19 *Enrico Fermi*

1901-1954

Achievement of the first controlled nuclear chain reaction in 1942—beginning of the nuclear age.



Trinity Site—the first nuclear device was exploded here, 16 July 1945

the history ie method of science and its applications

Many have used the method of science all through the history of mankind without being aware of having done so. These landmarks would show that the scope of the method of science has continuously increased over the last seven centuries or so, even though the basic steps in the method have remained unchanged. The method of science will find newer applications in the years to come, expanding the frontiers of human knowledge.

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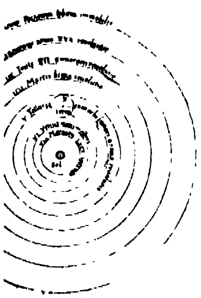
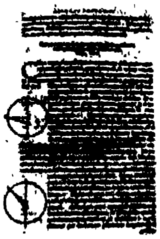


Copernicus' heliocentric system, from Copernicus *De Revolutionibus Orbium Coelestium*, 1543



A page from *De Revolutionibus*

4. *Francis Bacon*
1561-1626

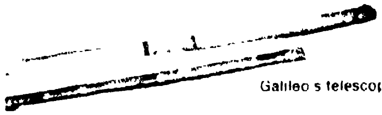
First formal statement of the method of science: the making of experiments, the drawing of general conclusions from them, and the testing of these generalisations through further experiments

5. *Galileo (Galilei)*
1564-1642

Beginning of the breach between science and religion first major victimisation of an outstanding scientist by religious leaders because of the views held by him (Galileo supported Copernicus and died under house arrest)

Galileo on the frontpiece of his *Istoria* 1613

Aristotle, Ptolemy and Copernicus on the frontpiece of Galileo's *Dialogo*, 1632 The book earned the wrath of the Roman Catholic Church



Galileo's telescopes

9 *The Industrial Revolution*
1760-1820

First largescale establishment of factories; application of the method of science to organised and efficient industrial production

A chartist demonstration Industry gave birth to the working class and democratic ideas

Watt's double-acting steam-engine

10. *Friedrich Wohler*
1800-1882

First demonstration, using the method of science, that substances made by living systems are not anything special they can be made in the laboratory from non-living materials

11. *Charles Darwin*
1809-1882

First major application of the method of science to the synthesis of a large body of descriptive information, enunciation of the theory of evolution and the idea that man has evolved gradually from lower forms of life A major confrontation with religion.

A finch from Darwin's *Journal of Researches*, 1845

14 *Fredrick Gowland Hopkins*
1861-1947

Discovery of vitamins foundations laid of the science of nutrition which tells us what to eat and how much of it to eat

15 *Vladimir Ilich Lenin*
1870-1924

Statement of the concept of planning for development and for achievement of social objectives

16 *Albert Einstein*
1879-1955

The beginning of the age of the "grand generalisations" in physics Statement of the theory of relativity

Einstein protesting nuclear weapons and lectureing at Princeton (above)

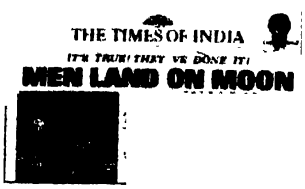
20 *James Watson* (1928-) and *Francis Crick* (1916-)

Determination of the structure of the genetic material (DNA) in 1953—beginning of the modern biological revolution.

Watson and Crick in front of the DNA model

21 *First man on the moon and his return to the earth*
July 1969

The most spectacular demonstration so far of the fact that science allows one to make testable predictions



THE TIMES OF INDIA

IT'S TRUE! THEY'VE DONE IT!

MEN LAND ON MOON

Armstrong's footprint on the moon—'in peace for all mankind'

22

?

You save Rs. 278 every year on fuel bills with a Hawkins® pressure cooker

Your Hawkins pays for itself in the first year

Solve your kerosene problem

Kerosene is difficult to get and costs a lot. Therefore, every effort must be made to use the minimum kerosene for cooking. Modern science has a solution.

Scientific, comparative cooking trials with the Hawkins pressure cooker have proved that on an average it consumes 53% less kerosene than cooking in the ordinary way. Because cooking with Hawkins takes less than half the time of ordinary cooking, you get similar savings if you use any other fuel—gas, coal, wood or electricity.

The best investment

By using a Hawkins, an average family can save over half a litre of kerosene per day. Saving on fuel alone would pay for your Hawkins in the first year itself. Since Hawkins is made to serve you for years and years, it is the best investment you can make today.

You need not worry if you have never used a pressure cooker before. Every Hawkins comes with a simple, illustrated instruction book, with 127 tested recipes. The book is available in 12 Indian languages.

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Hawkins gives the least trouble. The Hawkins gasket and safety valve last longer than in ordinary pressure cookers.

The special Hawkins design makes it accident-proof. Because the lid opens downwards into the pot instead of sideways, the lid cannot be opened even by mistake until the pressure inside falls to a perfectly safe level The safety valve is under the handle bar so that when it operates the steam is deflected safely downwards.

Free service

Hawkins has a written guarantee for 5 years. All parts covered by the guarantee are replaced free. Hawkins service is always free. There are Hawkins Authorised Service Centres with factory-trained mechanics in 115 towns in India who provide prompt expert service.

Invest in your family's health

You may not know it, but a Hawkins is also an investment in your family's health because it gives healthier food than ordinary cooking. Studies by the Central Food and Technological Research Institute show that certain nutritive elements, particularly vitamins and proteins, are better retained in pressure cooking. And Hawkins gives you more hygienic food because it cooks at 122°C, the temperature used for sterilisation.

Nowadays, you cannot afford to be without a Hawkins pressure cooker. Buy a Hawkins at your nearest, most trusted dealer or write to the manufacturers,
Pressure Cookers & Appliances Ltd., P.O. Box 1542,
Bombay 400 001.

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The trouble-free pressure cooker that's made to serve for years and years

LINTAS PCA 167-2518

Polyominoes

POLYOMINOES is the name given to a set of shapes constructed from a certain number of equal sized squares, each square being joined to at least one other square along an edge. Its study falls into a relatively recent branch of mathematics — combinatorics. In general, this branch of mathematics is concerned with the selection, arrangement and operation of elements (usually a finite number of them) into patterns under certain prescribed constraints.

Numerous articles have been written about polyominoes by various authors, but the credit initially goes to Solomon W. Golomb who coined the word "polyominoes" in 1953. He was then a graduate student and has ever since written and given many lectures on the subject, most of which he has compiled into an excellent book *Polyominoes* (published by Scribners in 1965).

Before we proceed further we need to examine the shapes obtained by connecting, say, *n* numbers of equal-sized squares along an edge. We would then obtain a set of shapes which can be classified as *n*-ominoes. Thus in the trivial cases when *n* = 1 or 2, we obtain one "monomino" and one "domino". When *n* = 3, we have two "trominoes," for *n* = 4 we have five "tetraminoes," and for *n* = 5, we have 12 "pentominoes." (Note that reversing and rotating a pattern does not give another pattern.) One can immediately see that the number of such patterns generated increases as the number of squares increase. No one has yet been able to find a relation between the total number of equal squares used and the total number of patterns thus generated but the number of possible patterns has been calculated (with the help of computers) upto $n = 12$ and these are shown in the Table.

Table

No. of squares	Possible combinations
1	1
2	1
3	2
4	5
5	12
6	35
7	108
8	369
9	1,285
10	4,653
11	17,073
12	63,000

The pentominoes seem to be the best suited for recreational mathematics, since their total number is neither too small (like in the tetraminoes) nor too unwieldy (as in the case of hexaminoes). Solomon W. Golomb has assigned letters to each of the 12 shapes obtained for pentominoes and suggests the following mnemonics to remember them — one needs to remember only the last seven letters of the alphabet (TUVWXYZ) and the word FILiPiNo, to cover the entire set, as shown in Fig.1. A set of pentominoes can be made very easily at home using stiff card, hardboard or thin plywood. An eight-by-eight square board will also be required to be made on which to arrange the pentominoes for certain types of problems. A chess-board would be an excellent substitute, but the size of the squares used for making the pentominoes should then be the same size as the individual squares on the chess-board.

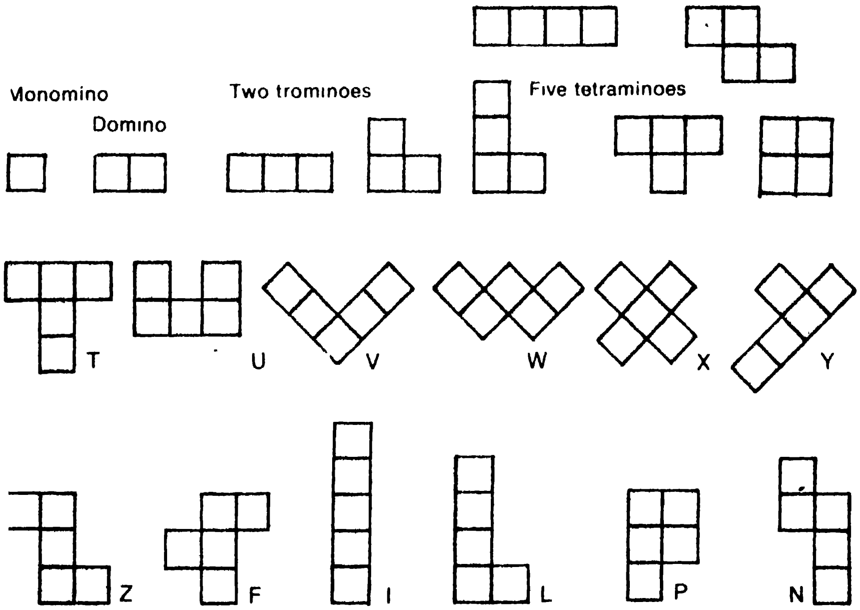


Fig.1 The shapes of the 12 pentominoes can be easily recalled by remembering TUVWXYZ, the last seven letters of the alphabet, and the word FILiPiNo

An interesting problem is whether the 12 pentominoes can be placed on a 8 x 8 chess-board leaving a two-by-two hole in the board. Note that the individual pentominoes can be rotated, reversed or flipped over in trying to solve the problems. A solution to the problem was discovered in 1935 and it is not yet known how many solutions there are, but it has been roughly estimated that there are at least 1,000. In 1958, it was shown by the use of a computer that there are 65 solutions in which the two-by-two hole is exactly in the centre. Fig.2(a) and (b) show two such solutions where the two-by-two hole is located at the favourite locations — the corner and the centre.

Each of the pentominoes covers five square units, and hence all the 12 cover 60 square units. The pentominoes can cover rectangles of size 10 x 6, 12 x 5, 15 x 4 and 3 x 20. The most difficult of these is the 3 x 20 rectangle. There are only two existing solutions, the uniqueness of which was shown by Dana S. Scott, Professor of Philosophy at the University of Stanford, California, using the MANIAC computer. Those readers who appreciate a difficult challenge would probably be interested in knowing that the total number of possible combinations for this problem, excluding forbidden positions and allowing for symmetry and rotation, comes to 12 factorial into 2^{21} or an approximate total of

(continued on p. 65)

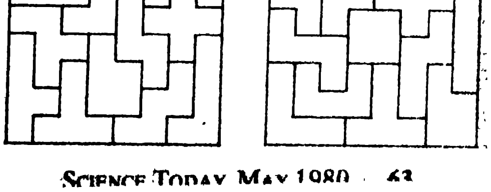


Fig.2(a) A solution of the chess-board problem with a hole in a corner and 2(b) with a hole in the centre

...how do birds build their nests?

Nest of the stone curlew hardly involves any construction. Her remarkably obliterative eggs range from pale buff to olive green, boldly blotched brownish or purplish

THERE are almost as many kinds of nests as there are of birds. We have, at one extreme, nests that involve no 'building' at all. Various sea birds that breed on rocky islands just lay their eggs on a flat ledge of bare rock. At the other extreme, we have those marvels of avian architecture, the neat purses made by the flowerpeckers (*Dicaeum* species) of vegetable fibre, seed-down, cotton and cobweb, and the expertly woven, retort-shaped nests of the baya sparrow (*Ploceus philippinus*).

Quite as amazing are the nests of certain swifts (Apodidae). The familiar palm swift (*Cypsiurus parvus*) gathers seed-down from the air as it flies about, glues it with its own saliva to one of the numerous folds in a palmyra leaf and sticks its eggs to this, also with its quick-drying glutinous saliva. Some swifts of the genus *Collocalia* (well-known as the sources of that Chinese delicacy, birds' nest soup) use only pure saliva to make crystalline cradles for their eggs and their young.

Writers of bird-books often remind us that there are weavers, tailors, masons, carpenters, miners and even robbers among birds. The baya sparrow, already referred to, collects thousands of strips of grass or of palm leaf and actually weaves them together using its beak and feet. The tailor bird (*Orthotomus sutorius*) fastens the edges of one or more broad leaves together to form a cone inside which it builds a nest of fibre, seed-down, feathers and cotton. Among the hornbills (Bucerotidae), the female enters a large cavity in some tree and, using her outsized bill as a trowel and her own droppings for cement, plasters up the entrance leaving only a narrow vertical slit. Through this slit her mate feeds her during her weeks of self-imposed imprisonment, and when the eggs hatch, the young ones as well. The woodpeckers (Picidae) and the barbets (Capitonidae) peck out neat holes in the trunks and branches of trees using their bills more or less as a carpenter employs a chisel, while the kingfishers (Alcedinidae) and bee-eaters (Moropidae) drive long tunnels into the earth.

There are also some birds that are habitual usurpers of the old nests of other birds. Various kinds of mynas (Sturnidae) often seize for their own use the occupied nests of woodpeckers and other birds.

The Indian tailorbird 'sews' up broad leaves using its bill to make a nest (Photos on this page courtesy: E.T. Gilliard, *Living Birds of the World*)

Cuckoos (Cuculidae) and a few other parasitic birds never build nests of their own. They simply lay their eggs among those of other species, shirking all domestic responsibilities.

Young European cuckoo removing egg from the nest of a tree pipit. A cuckoo not only lays her egg in another bird's nest, but when the egg hatches the young cuckoo heaves out other eggs or 'legitimate' offspring — usually of a smaller species — from the nest

The variations in nest building are endless. Let us, therefore, see how one species, the purplerumped sunbird (*Necterinia zeylonica*), common all over India, builds its nest. Here, the male sunbird takes no share in nest building. It is the female who selects the site, collects material, and converts it into what may appear to be an accidental accumulation of dead leaves hanging at the tip of a twig. That is because the exterior of the nest is mostly made of bits of dry leaves stuck together with cobweb.

This outer case or envelope is what the bird makes first. Once she has selected a sunbird gathers, among other things, fine grass stalks, thin fibre and hair and fixes these to the twig until some six to 10 cm of the tip of the twig are covered.

The bird does not weave material around the twig, but sticks it together by a generous use of cobweb. As more material is added, the stalk of the nest becomes thick at its lower extremity. By the addition of more and more material the bird makes a bag some 13 cm long. At this stage the nest resembles "nothing so much as a deflated penny balloon" (see *Jour. Bom. Nat. Hist. Society* **55** 3). To the outside of this has been stuck, in a most haphazard manner, pieces of lichen, masses of dried caterpillar castings, little bits of bark and, often, paper. There will be something like a vent on one side. It is through this opening that the bird frequently thrusts its head when making the outer shell. Later, this becomes the entrance to the nest.

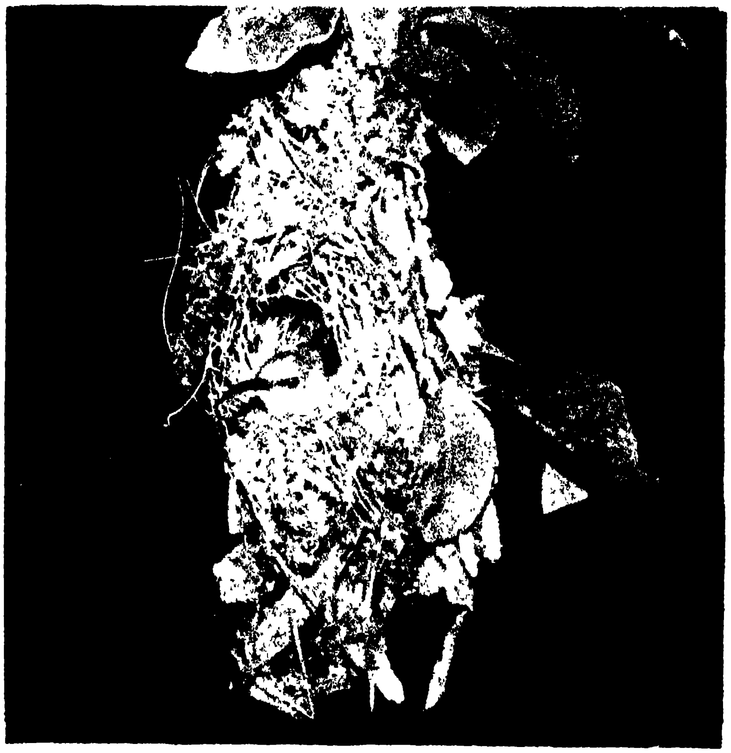
It may take the bird three or four days to make the shell. When this has been finished, she collects seed-down, cotton and other such soft stuff and, presumably, fixes them to the inner side of the shell with cobweb. During this period she enters the nest, and, by raising her wings and pushing with her head and tail, gives the bottom and the sides of her new home a roughly globular shape. She strengthens the lower rim of the entrance by adding more fibre and pressing it down with her chin and throat. When the lining of the shell is completed, there is a thick, smooth and silky-soft inner wall of cotton and seed-down.

The nest is now ready to receive the first egg.

K. K. NEELAKANTAN

Prof Neelakantan is President, Kerala Natural History Society, Trivandrum, and a distinguished ornithologist

Purplerumped sunbird sitting on her eggs. Quite unlike the stone curlew, the sunbird takes six to 12 days to construct its untidy-looking pendant nest. Materials used for nest-building could include grass, hair, lichen, caterpillar castings, bark and paper



V K Suresh Kumar

(continued from p. 63)

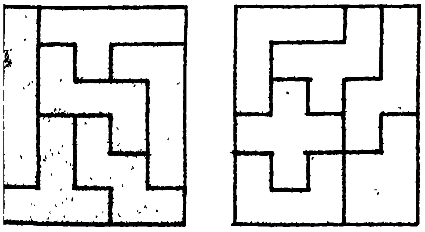
1,004,539,160,000,000 combinations. (Solution will appear next month.)

Another programme, run by C.E. Haselgrove of the University of Manchester showed that there are a total of 2,339 solutions for the 6 x 10 rectangle and Fig.3 shows one such solution. Finding out one other solution should not be very difficult! Since there are a large number of possible solutions, certain constraints were added to make the problem more challenging. For instance, divide the pentominoes into two groups of six each and construct two 6 x 5 rectangles with them. These two 6 x 5 rectangles can be combined to give either a 6 x 10 or a 5 x 12 rectangle. Fig.4 shows the solution to the problem.

Another interesting problem, the triplication problem, was posed by R.M. Robinson of California University. Out of the 12 pentominoes, any one is selected and from the remaining, a three times larger scale model of the selected pentomino is constructed using only nine pieces (excluding the selected one). Triplication of all the pentominoes is possible and Fig.5 gives you a "tip" as to how to go about solving the problem.

Pentominoes can be endlessly fascinating, and we will come back to some more pentomino problems next month.

K.N. MALATHI



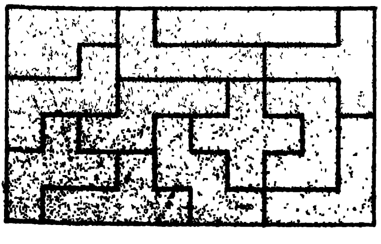


Fig.3 (above) and Fig 4(top)

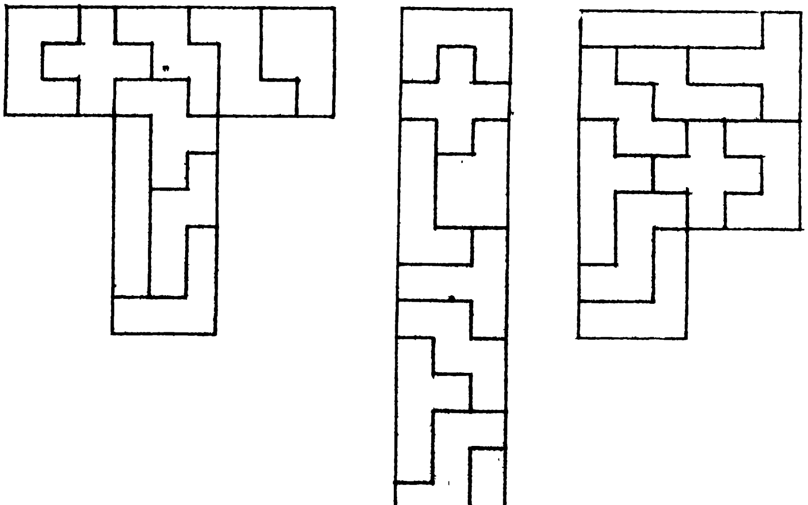


Fig.5 A "tip" on how to solve the triplication problem

How thermal stress affects workers

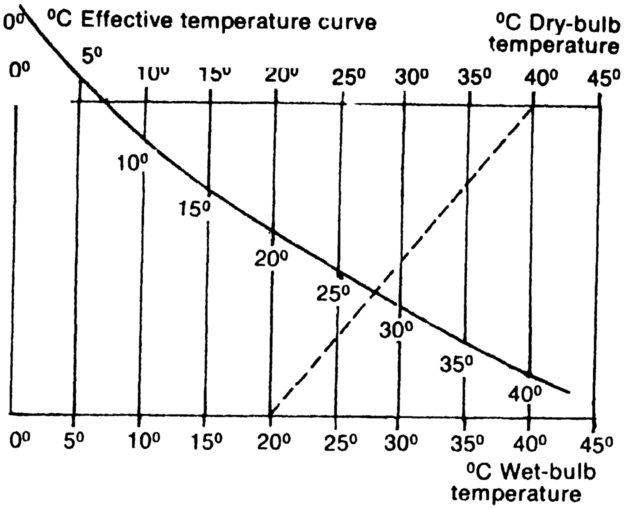
Evaluation of thermal stress on workers should help frame productivity norms that are fair to workers

Krish Pennathur

WITH the onset of the hot Indian summer, most people tend to get tired very easily. This is because optimal performance in human beings can only take place within certain temperature ranges and being warm-blooded animals with a skin surface temperature of 37°C, any substantial environmental deviation from it affects our performance adversely. If the temperature around goes up, so does the temperature of the body. We sweat, and perspiration is the body's mechanism for losing heat. Beyond a point of exposure, both in terms of time and intensity, the sweat glands tire and fail. The body cannot endure the stress, and fatigue sets in. In addition to simple exposure, the kind of work undertaken and the metabolic rate being generated as a result, is another factor which raises body temperature.

What does this fatigue mean for production? Errors creep into work, the rate of output diminishes, aural and optical abilities are impaired. The total span of working life, and life itself, is reduced as a result. What have been the solutions commonly applied in such situations? One approach is to alter environmental factors such as temperature, humidity and air velocity. Another approach is to compensate for induced fatigue by way of relaxation allowances.

Relative humidity and the velocity of air are two climatic factors that affect our tolerance to ambient temperature. When the relative humidity is low, higher temperatures can be tolerated. And if the rate of air circulation is high, a higher temperature can be tolerated even if it is accompanied by fairly high relative humidity. This subjective feeling of warmth and cold is taken into account in what is called the effective temperature. This correlates the temperature, the relative humidity and the velocity of air (see figure). When the relative humidity is 100 per cent and the air velocity is zero, the effective temperature will be the same as the ambient temperature. A reduction in relative humidity or an increase in air velocity, or both, would bring down the effective temperature. In this article, temperature indications are in terms of effective temperature.



The effective temperature correlates relative humidity and air velocity with the ambient temperature. Measure the temperature of air and water vapour on a dry-bulb thermometer and the temperature due to cooling from water evaporation on a wet-bulb thermometer. Join the two temperature readings on the accompanying scales by a straight line. The point at which it intersects the curve is the effective temperature. In this example, the wet- and dry-bulb readings are 20°C and 40°C and the effective temperature 28°C

The comfort temperature and the temperature at which a person can work without loss of efficiency are different. There is no decrease in the efficiency of work until the temperature is several degrees higher than the comfort temperature. Similarly, the rate of performance does not drop off till the temperature is some degrees below the comfort zone. Beyond these tolerance limits (15° and 33°C), the output falls and the errors increase rather steeply. For heavy manual work, the drop in efficiency is pronounced above 29°C. Similarly, the performance drops for effective temperatures below 10°C.

Table 1: Relaxation allowances for temperature and humidity

Temperature (°C)	Relative humidity (%)	Relaxation allowance (%)
Below 0	30 - 70	Over 10
Below 0	Over 70	Over12
0 - 12	30 - 70	10 - 0
0 - 12	Over 70	12 - 5
13 - 23	30 - 70	0
13 - 23	Over 70	5
24 - 37	30 - 70	0 - 40
24 - 37	Over 70	5 - 100
Over 37	30 - 70	Over 40
Over 37	Over 70	Over 100

The rule-of-thumb allocation of relaxation allowance, as a percentage of the basic time required to carry out a job

Lack of fresh air can affect performance by about nine per cent. A normal person requires about 40 cubic metres of fresh air per hour. As a general rule, there must be a complete air change once every 20 minutes in any office or factory.

No positive research findings have been found so far in respect of the effects of thermal stresses on mental load. For want of anything better, office workers are treated as light sedentary workers with the comfort zone placed between 24° and 28°C.

In conditions of dry heat, when the humidity is low, and hence the effective temperature is high, fans do not afford much relief. Humidity has to be artificially induced to provide relief. Thus, desert coolers are effective in dry heat.

In conditions of humid heat, ceiling fans, pedestal fans, exhaust fans, induction fans, etc are used for a constant displacement of air. The higher a ceiling fan is fitted, the greater is the floor area swept but air displacement is lower. Relief provided by pedestal fans is greater because the area of exposure is more. In assembly lines, pedestal fans with lines of sweep at 15° to the assembly line are most effective. In a group area, like a bench fitting shop, ceiling fans that provide for a rate of air displacement around one metre per second give moderate relief.

A study of relaxation allowances needed for different types of climatic conditions in India was taken up by the author. The study was conducted in three phases: industrial survey, [illegible] pth study in three selected industries. Outlined below are some of the findings.

Industrial survey : The broad conclusions that were drawn from the results of this survey are as follows.

i) The output of Indian workers is pronouncedly influenced by climatic factors.

ii) Whereas high temperatures at low relative humidities (40.5°C in May in Delhi) seem to be reasonably tolerated, lower temperatures, at higher relative humidity levels (about 32°C in July and August in Calcutta) affected the output appreciably.

iii) The fall in output due to thermal stresses is appreciably more in cases where heavier physical effort is needed than in cases of lighter manual effort.

iv) In some of the centres selected for the survey, thermal stresses affected the production output by as much as 30 per cent. The average decline in production, compared to the maximum for any month, that could possibly be attributed to thermal stresses appear to be : Calcutta 19 per cent, Delhi 20 per cent, Madras 16 per cent, and Bangalore 7.5 per cent.

v) The fluctuations in production in a temperate climate with low humidity are very much less than in climates which are hot or hot-humid or which experience a wide variation in temperature and humidity between summer and winter. This is supported by the sample variance in production output for each centre : Calcutta variance 50, Delhi 58, Madras 30, and Bangalore 7.6.

Laboratory experiments : For the first time an attempt has been made to establish the quantum of relaxation allowance needed by workers, to compensate for thermal stresses, at close intervals of effective temperature ranging from 12°C to 42°C. The results of this research study have confirmed that the requirement of relaxation allowance varies with increase in effective temperature. But the increase in relaxation allowance is not a linear function of effective temperature. According to our experiments, the difference in relaxation allowance for light work is three per cent per degree at 30°C but at 40°C it is 16 per cent per degree.

In the past no special effort had been made to assess the requirements of relaxation allowance due to thermal stress for different levels of energy expenditure by workers. The study revealed that even after allowing relaxation allowance for energy input [illegible] a separate factor, differences in energy input have a further influence on the relaxation allowance needed for thermal stresses. For the same effective temperature, the relaxation allowance needed on account of thermal stresses only increases with increase in energy input. At 30°C, the relaxation allowances for thermal stresses are seven, 21 and 31 per cent for 'light', 'moderate' and 'heavy' work respectively (that is, physical energy outputs of 2.6, 5.1 and 10.3 kilo-calories per minute respectively).

Ergonomists are unanimous that whenever thermal conditions necessitate an increase in relaxation allowance by over 7.5 per cent, action should be taken by managements to reduce the thermal stresses. Based on this, effective temperatures above which Indian managements should take action to control thermal conditions would appear to be 31°C for 'light' work, 29°C for 'moderate' work and 28°C for 'heavy' work. We also found that the workers were most comfortable when the temperature, while at work, was 24°C for 'light' work, 20.5°C for 'moderate' work and 18°C for 'heavy' work.

Table 2: Synthesised scale of additional relaxation allowances required to compensate for thermal stress

Effective temperature (°C)	Relaxation allowance (% of basic time)		
	Light work	Moderate work	Heavy work
22	0	0	0
23	0	0	0
24	0	0	1
25	0	0	2
26	0	1	3
27	0	2	5
28	0	4	7
29	2	8	13
30	4	14	21
31	7	21	31
32	12	30	44
33	19	42	59
34	26	55	78
35	34	72	99
36	42	90	126
37	51	111	153
38	60	135	194
39	72	161	229
40	88	188	254
41	104	219	295
42	127	251	341

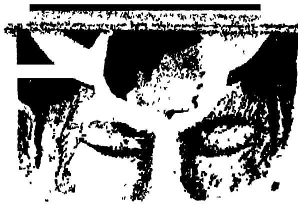
The quantum of additional relaxation allowance needed to compensate for thermal stresses derived from the industrial survey and the laboratory do not vary appreciably. However, figures for 'light' and 'moderate' work from the industrial study are a bit lower than those from the laboratory. In the case of 'heavy' work, the industrial study indicates slightly lower amounts of relaxation allowance up to 35°C and slightly higher amounts above 35°C, when compared with laboratory results.

Among the many reasons for the difference in the results three factors are worth noting. Firstly, the workers in the industrial cases were acclimatised to the climatic conditions. This could have been a major contributory factor for the divergence. Secondly, in the industrial cases studied, production control was fairly strict and there was great pressure of demand for output. There is a third factor which may be of significance to industrial managers. Experienced workers know that their output falls during the summer. Rather than be held accountable for appreciable shortfalls in production in summer months, they could have tended to regulate their pace of work so as to avoid great disparities in output between the winter and summer months. This feeling was indeed voiced by some of the workers in the discussions we had with them.

Which of the two scales of additional relaxation allowance for thermal stresses should be treated as being more accurate? There is no sufficiently reliable basis to determine whether one or the other is more precise. Since the correct and fair approach of management should be to give workers the 'benefit of the doubt', a reasonable guide for relaxation allowance would be a scale derived from the results of both the industrial study and the experimental work, with the higher value from either taken as the allowance for each effective temperature. Table 2 has been prepared on this basis and it could be treated as a guide in the assessment of relaxation allowances to compensate for thermal stresses.

This effort to establish the quantum of relaxation allowances at different levels of performance and at effective temperatures ranging from 22°C to 42°C in steps of 1°C will hopefully help to set productivity norms that are fair to the workers.

Dr. Pennathur is currently coordinating the Commonwealth Reasearch Programme on Standard Rate Performance of Workers. He is also engaged in certain facets of ergonomic research based on the Indian socio-industrial environment.



The Doctor as Detective

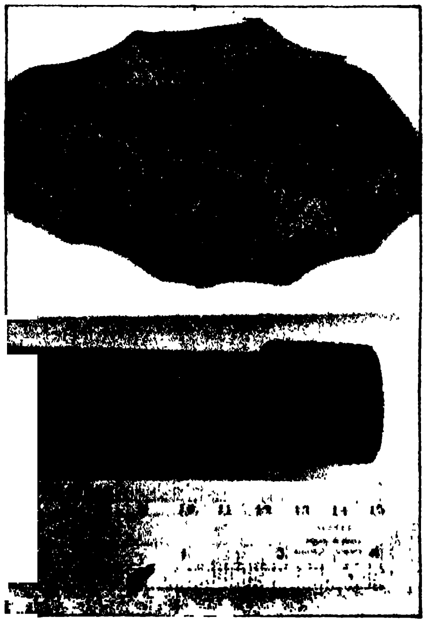
The cause of death

Pritam P. Phatnani

The fifth W in the series deals with the cause of death

FROM the injuries on the dead body it was obvious that the man had been assaulted with a long weapon like a lathi. However, there was an injury on his back which looked like a dagger laid on its flat side (see picture below). At first it was thought to be due to an iron pipe with one end having threads. It was decided to preserve the skin for further study. A search was made for a lathi-like weapon, and, sure enough, one was found—a lathi with a threaded iron ring at one end. It matched perfectly with the impression on the skin (seen in the picture) except for an area of skin which bore no impression because it had not come in contact with the weapon as a result of the difference in the thickness of the ring and the lathi.

There were two other cases, in one of which a pickaxe had been used and in another, a forked jemmy. In both these cases the injuries were matched with the weapons and the blood stains found on the weapon matched with the blood group of the respective victims. These are only a few cases where the lethal weapon has been linked with the crime.



Dagger-shaped injury on the skin matches perfectly with the lethal weapon, a lathi with iron ring.

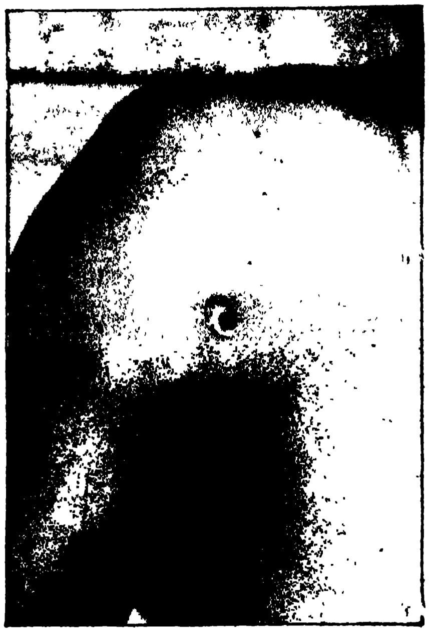
In the investigation of a crime, no less important than the identity of the dead, the time and place of the crime and the motive for it, is the cause of death. Where a weapon has been used, it is essential for the prosecution to produce it and link it with the crime. Establishing the cause of death also reveals the circumstances of death and thus helps in reconstructing the crime.

Broadly, a person can be killed by mechanical means or by chemical means. In poisoning cases the doctor has to find out, with the help of the chemical analyser, which poison had been used. In cases of mechanical violence, the weapon used for committing the crime has to be found, if it is not present at the scene of crime; when it is found, it has to be linked with the crime beyond any doubt, thus establishing the guilt of the accused. At times, the crime is committed with bare hands.

Even a careful external examination of the body can offer the most valuable clues. The colour of the postmortem staining (see SCIENCE TODAY, February 1980, p. 58) can indicate the poison used. For example, it is a pinkish hue in the case of carbon monoxide poisoning and brown in the case of methhaemoglobinimia. In opium poisoning there is intense blue, specially that of the face. The whole body may become red when there is rifampin poisoning. Appearance of a blood stained froth with kerosene-like smell is an indication of death due to an organophosphorous compound. In the internal examination, the appearance of the internal lining of the stomach gives an indication of the poison used. It is blue in the case of copper sulphate and blood-red in cyanide poisoning. Some poisons like the organophosphorous compounds also emit peculiar smells. Phosphorus gives out a garlic-like smell and opium emits a groundnut cake-like odour. These are subsequently confirmed by chemical analysis.

That mechanical violence has been used becomes quite obvious from the external injuries generally. However, at times this can be determined only by internal examination. In such cases a careful examination is required to establish the facts. Sometimes in an attempt to give a colouring of suicide, a corpse is burnt or placed on a railway track.

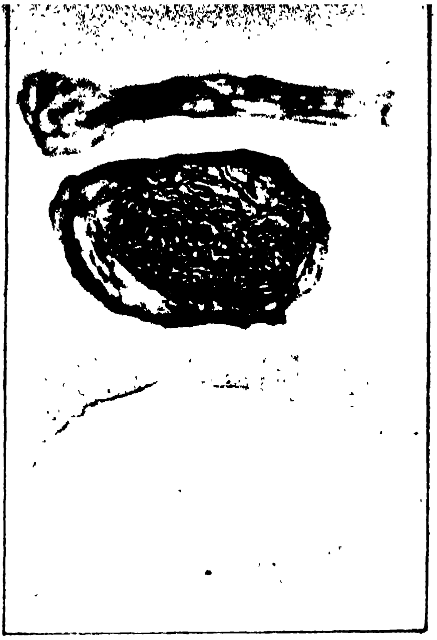
If more than one weapon has been used, then it has to be established which weapon caused the death of the individual. This will help in fixing the criminal responsibility when there is more than one accused and they have used different weapons on the same victim. Besides, by studying the track of the wound one can reconstruct the direction in which the blow was inflicted and establish the relative position of the victim and the assailant. In the case of firearm injuries, the distance at which the gun was fired can be determined and the entire crime could be reconstructed.



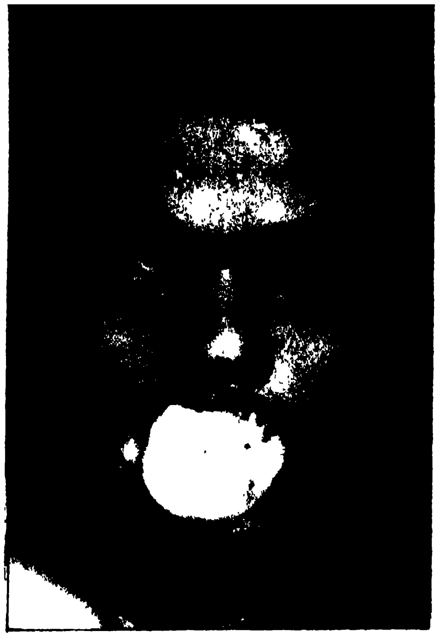
Entry wound caused by a 0.303 rifle bullet

The nature of the weapon used can be determined by the physical character of the injury. Hard and blunt objects like lathis, stones, rubber hoses or iron bars cause abrasions, bruises, lacerations and also fractures. Injuries from lathis and iron bars are in the shape of two parallel lines. Knives and other sharp-bladed or pointed and tapering weapons

Nail marks on the neck in strangulation with bare hands



In cyanide poisoning (top) the stomach is blood-red inside, compared to normal stomach



Blood stained froth at the mouth in poisoning by organophosphorous compound

inflict "incised", or "stab" wounds. Incised wounds are shallow and long, whereas stab wounds have more depth than length. Incised wounds are also clean cut with regular margins, compared to the lacerated wounds which are tears in the skin with irregular margins.

Firearm injuries have their own peculiarities, depending upon the type of gun and the ammunition. The injury caused by a rifle differs from that caused by a shotgun. Shotgun ammunition could have single or multiple pellets. The nature of the injury also depends on the distance of the victim from the gun when it is fired.

When a gun is fired in contact with the body, as generally happens in suicide cases, one can see the muzzle impression around the wound, the point where the bullet had entered the body. When the gun is fired within 15 to 25 cm of the body, the skin around the entry wound of the bullet is scorched by the flame emitted from the muzzle. Even when the gun is fired from a few metres away one can see the gun powder tattooing (impregnation of the gun powder in the skin) around the wound. In the case of a shot fired from a longer distance, none of these marks are visible except the bullet hole. The dispersion of the multiple pellets of the shotgun also give an idea of the distance between the victim and the gun. The felt wad pieces ejected from the shotgun cartridge also inflict burns on the victim's body if fired from within four to five metres. In some cases, the bullet comes out from the body. The point where it comes out, the "exit wound" has characters different from the entry hole; there is no scorching or gun powder tattooing. The direction from which the gun was fired can be determined from the entry wound and the course of the bullet within the body if it is not deflected by a bone.

Often some weapons are peculiarly shaped or have a tell-tale mark, which are reflected in the shape or size of the injuries. These injuries serve as the "finger prints" of the weapon and help a great deal in the identification of the actual weapon used for committing the crime.

There are cases where no weapon is used, the killer using his bare hands, as in strangulation or throttling, as it is called when done with hands. One often finds nail marks corresponding to the position of the hands and internal injuries in the throat which is crushed by the murderers to keep the victim from shouting. The internal injuries in the neck like the fracture of the hyoid bone are characteristic in strangulation.

In hit-and-run cases, where a vehicle driver after knocking down a man, generally by accident, bolts from the scene, the cause of death is established from the nature of the injuries and the involvement of the vehicle from the impressions of the tyre marks, etc left on the body. However, such cases and bodies found on the railway tracks need a very careful postmortem examination to rule out attempts to make a murder pass off as a case of suicide or accident involving the vehicle.

Bus tyre marks left on the arm of a victim in a hit-and-run accident

Pickaxe injury on the top of the head

Deaths taking place in police custody, remand homes, asylums and beggars' homes need a very careful study in the interest of society, and in such cases the forensic pathologist's responsibility in arriving at the correct cause of death is much greater. Recently there was a case in which a death of a beggar in the receiving centre was certified by their doctor as natural but the postmortem examination established it to be due to mechanical violence. The case was tried in a court and the persons responsible for the death of the beggar were duly convicted.

Dr Phatnani heads the medical education division of a well-known pharmaceuticals firm and is guest lecturer in Forensic Medicine at the Seth G.S Medical College, Bombay.

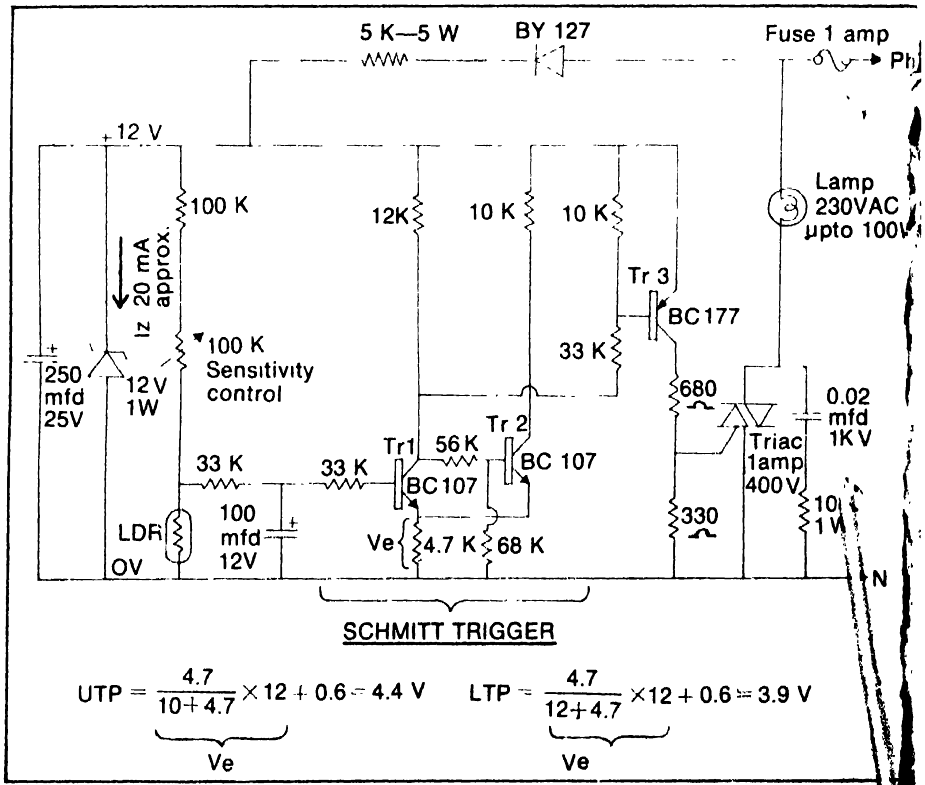
Automatic twilight lamp

THE automatic twilight lamp described below is a very simple and fully solid-state device. Instead of an electromagnetic relay, the triac used in the device switches the lamp. The Schmitt trigger stage, using two transistors, provides flickerless "on" and "off" operation of the lamp.

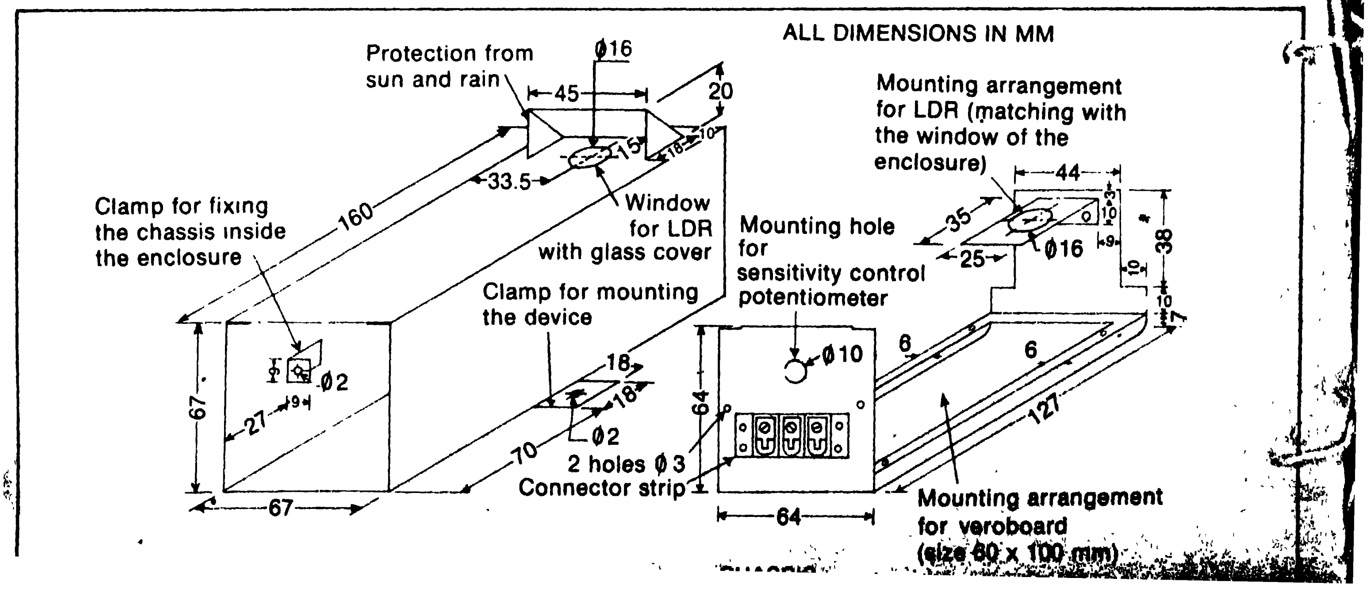
The 12 volts DC supply required for the three transistors and the associated light sensing circuit is derived directly from the 230 V AC mains supply. The half-wave rectification of the mains supply, through a 5K - 5 watt voltage drop resistor, provides sufficiently stable and smooth DC supply across parallel combination of 12 V Zener diode and the 250 mfd capacitor, thus eliminating the use of bulky step-down transformer.

The light-sensing circuit consists of a voltage divider comprising of a 100 K resistor, a 100 K potentiometer and a LDR connected in series as shown in the diagram. When the light falls on the LDR, its resistance drops to such a low value that it virtually provides no voltage drop across it. As the sun goes down, the intensity of the light falling on the LDR reduces. This increases the resistance of the LDR and the voltage across it also increases. The voltage provided across the LDR is fed, through a resistor-capacitor configuration, to provide the necessary time delay of a few seconds, to the base emitter circuit of the first transistor Tr1 of the Schmitt trigger stage. The delay is for avoiding abrupt operation of the device due to shadows or reflections of moving objects falling on the LDR. When this voltage reaches 4.4 V (see box) it brings the transistor into conduction. As the transistor comes into conduction, the voltage drop across its collector-resistor increases and the voltage drop across its collector-emitter falls. The former, that is, the increase in the collector-resistor drives the transistor Tr3 in conduction and the latter, that is, the fall in the voltage drop across the collector-emitter of the transistor Tr1, brings the transistor Tr2 out of saturation. The change of conducting state from Tr2 to Tr1 and the difference in the ohmic values of their collector resistances causes a fall in their common emitter voltage. This drives transistor Tr1 into saturation and Tr2 into complete non-conductive state. The conducting transistor Tr3 drives sufficient current through the gate circuit of the triac and the triac switches on the lamp. The lamp, once **lighted, remains "on" due to the hysteresis provided by the Schmitt trigger action, till the intensity of light falling on the LDR increases sufficiently, so that the voltage provided across the LDR falls below 3.9 volts. This feature avoids the flickering of the lamp during twilight.**

After completing the circuit on a veroboard, the LDR can be mounted on the bracket as shown in the photograph. The LDR mounting bracket is fixed in such a way that when the chassis is inserted in the enclosure, the LDR comes just opposite to the circular window. The device now should be installed in such a way that the LDR will receive maximum natural daylight but not direct sunlight. At the same time, see that the light of the lamp operated by this device does not interfere with the LDR. Now adjust the sensitivity control for optimum result.



$$\text{UTP} = \underbrace{\frac{4.7}{10+4.7}}_{\text{Ve}} \times 12 + 0.6 = 4.4\ \text{V} \qquad \text{LTP} = \underbrace{\frac{4.7}{12+4.7}}_{\text{Ve}} \times 12 + 0.6 = 3.9\ \text{V}$$



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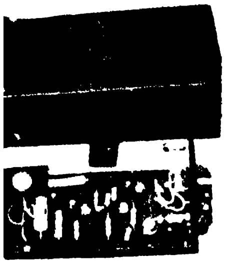
45
20
10
18
15
33.5
160
Window for LDR with glass cover
Clamp for fixing the chassis inside the enclosure
Mounting arrangement for LDR (matching with the window of the enclosure)
44
35
ϕ16
25
10
9
38
10
10
17
Mounting hole for sensitivity control potentiometer
Clamp for mounting the device
ϕ2
9
27
67
18
18
ϕ2
70
2 holes ϕ3
Connector strip
67
64
ϕ10
6
6
127
64
Mounting arrangement for veroboard (size 60 x 100 mm)

Caution:- **Since the complete circuit operates directly on the mains supply, do not touch any part of the circuit when it is connected to the mains supply.**



The twilight lamp and its enclosure

You will need

Semiconductors: Triac 1 Amp, 400V -1 No.; Transistors BC107 - 2 Nos.; BC177 - 1 No.; LDR - 1 No.; Zener diode 12V, 1 W - 1 No.; Rectifier BY127 - 1 No.
Capacitors: 250 mfd, 25V - 1 No.; 100 mfd, 12V - 1 No.
Resistors· 5K, 5W - 1 No. Following all half watt: 100K - 1 No.; 68K - 1 No.; 56K- 1 No.; 33K - 3 Nos.; 12K - 1 No.; 10K - 2 Nos.; 4.7K - 1 No.; 680 ohms - 1 No. and 330 ohms - 1 No.
Potentiometer 100K carbon linear - 1 No. (Approximate cost of the above electronic components in Bombay market, Rs. 95).
Misc Enclosure as shown in the diagram, solder, wires, screws, lamp 100W with lamp-holder, connector strip, 3-way fuse 1 amp with fuse-holder, veroboard, 60 x 100 mm, etc.

ANIL V. BORKAR

How the Schmitt trigger circuit works

When the input voltage, fed through the 33K resistor to the base of the transistor Tr1 is zero, the transistor remains cut off. As the input of transistor Tr2 is connected, through 56K and 68K voltage divider, across the collector-emitter of Tr1, the transistor Tr2 remains in saturation. With Tr2 saturated, its collector-emitter is effectively shorted together. As a result, the voltage "Ve" across the common emitter resistor of 4.7K can be calculated by considering the voltage divider action which is 3.8 V. Thus, it should be clear that for any value of input voltage less than $3.8+0.6=4.4$V, 0.6 volts added being the forward bias voltage required for the silicon transistor Tr1, there can be no base current through Tr1. Thus, the transistor Tr1 remains "off" and the transistor Tr2 remains saturated.

If the input voltage is raised above 4.4 volts, base current can flow in Tr1. Once this happens, its collector current increases and the voltage at its collector emitter decreases. This drop brings the transistor Tr2 out of saturation. The reduced collector current of Tr2 also reduces the common emitter voltage Ve. As 'Ve' gets reduced, Tr1 goes more into saturation. The regenerative process continues till Tr1 becomes fully saturated and Tr2 cut off. This changeover of the saturated state, from Tr2 to Tr1, because of difference in ohmic values of their collector resistors, reduces the common emitter voltage 'Ve' from 3.8 to 3.3V.

As the common emitter voltage 'Ve' is reduced to 3.3 volts, the input voltage to transistor Tr1 has to be reduced to less than $3.3+0.6=3.9$ volts, to bring the transistor out of saturation. When the input voltage is reduced below 3.9V, the collector-emitter voltage of Tr1 increases, causing Tr2 to conduct. With Tr2 coming into conduction, the common emitter voltage 'Ve' increases causing the collector current of Tr1 to reduce further. This once again causes a regenerative action which continues till Tr1 is cut off and Tr2 is saturated. Thus, the circuit comes back to the original condition.

The value of input voltage which changes the saturated state from Tr2 to Tr1 is called the upper trigger point (UTP) Similarly, the value of input voltage which brings the circuit back to the original condition is called lower trigger point (LTP)

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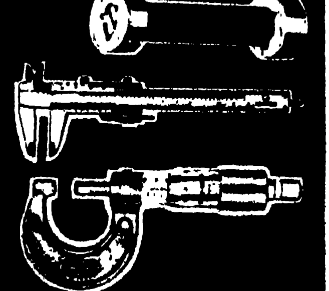

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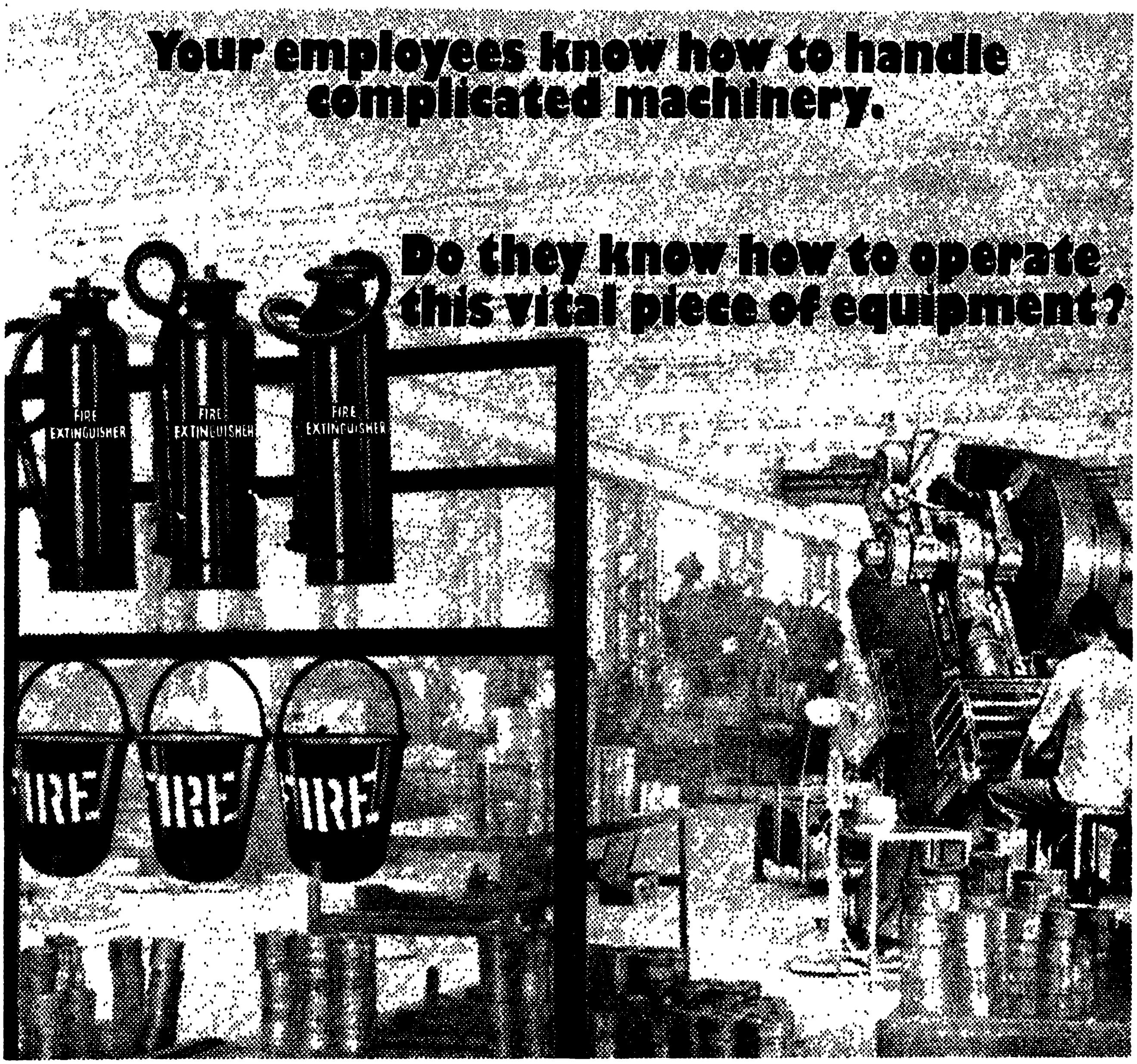
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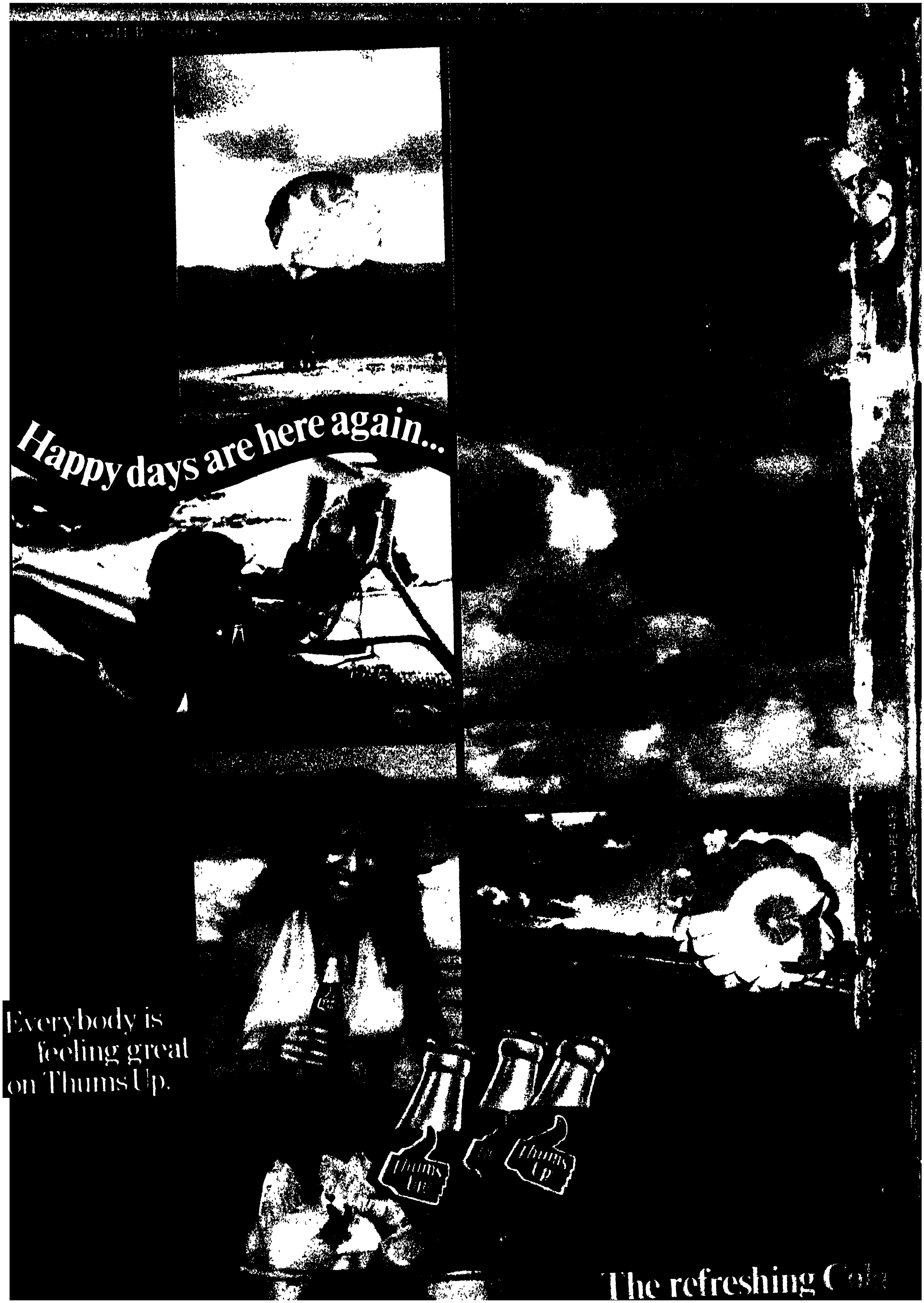

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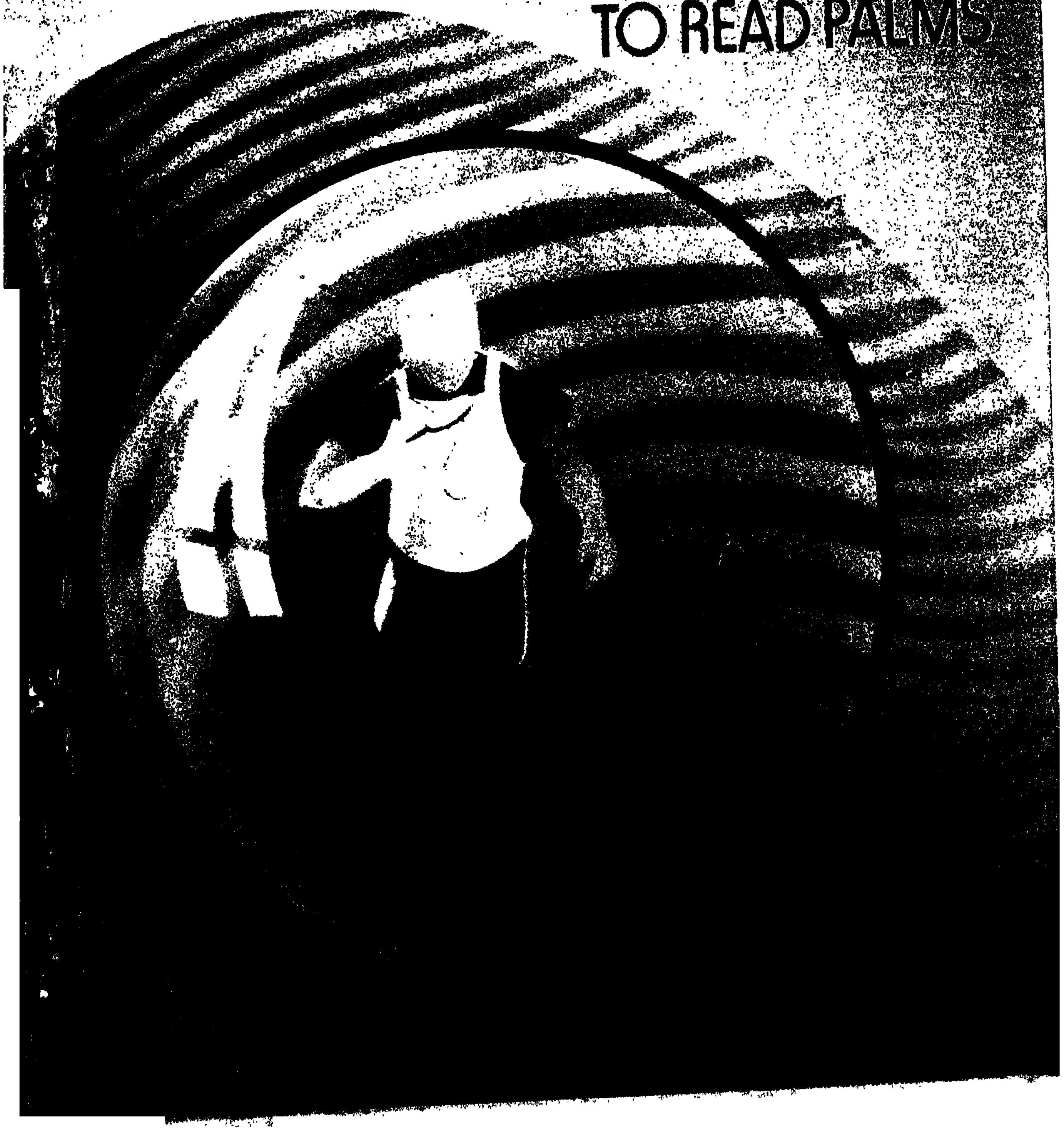

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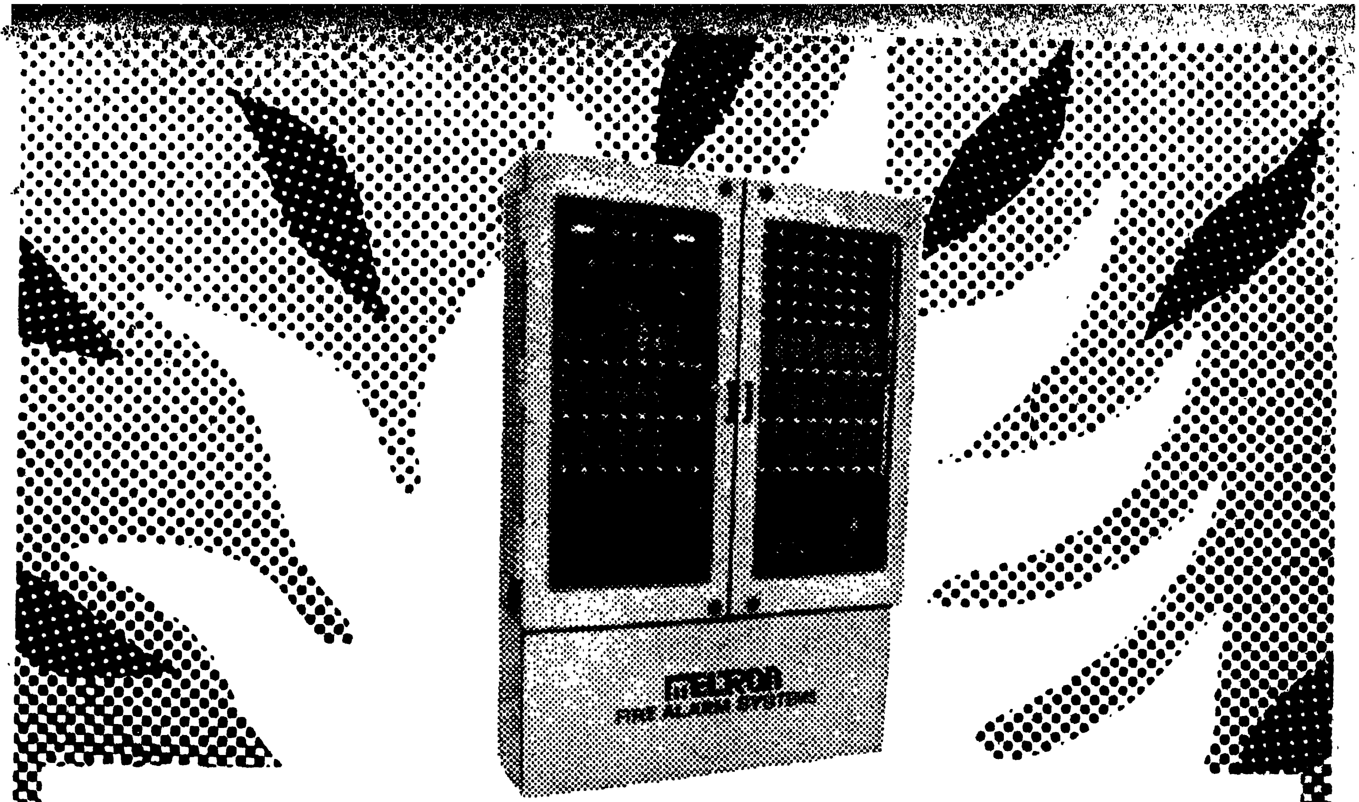

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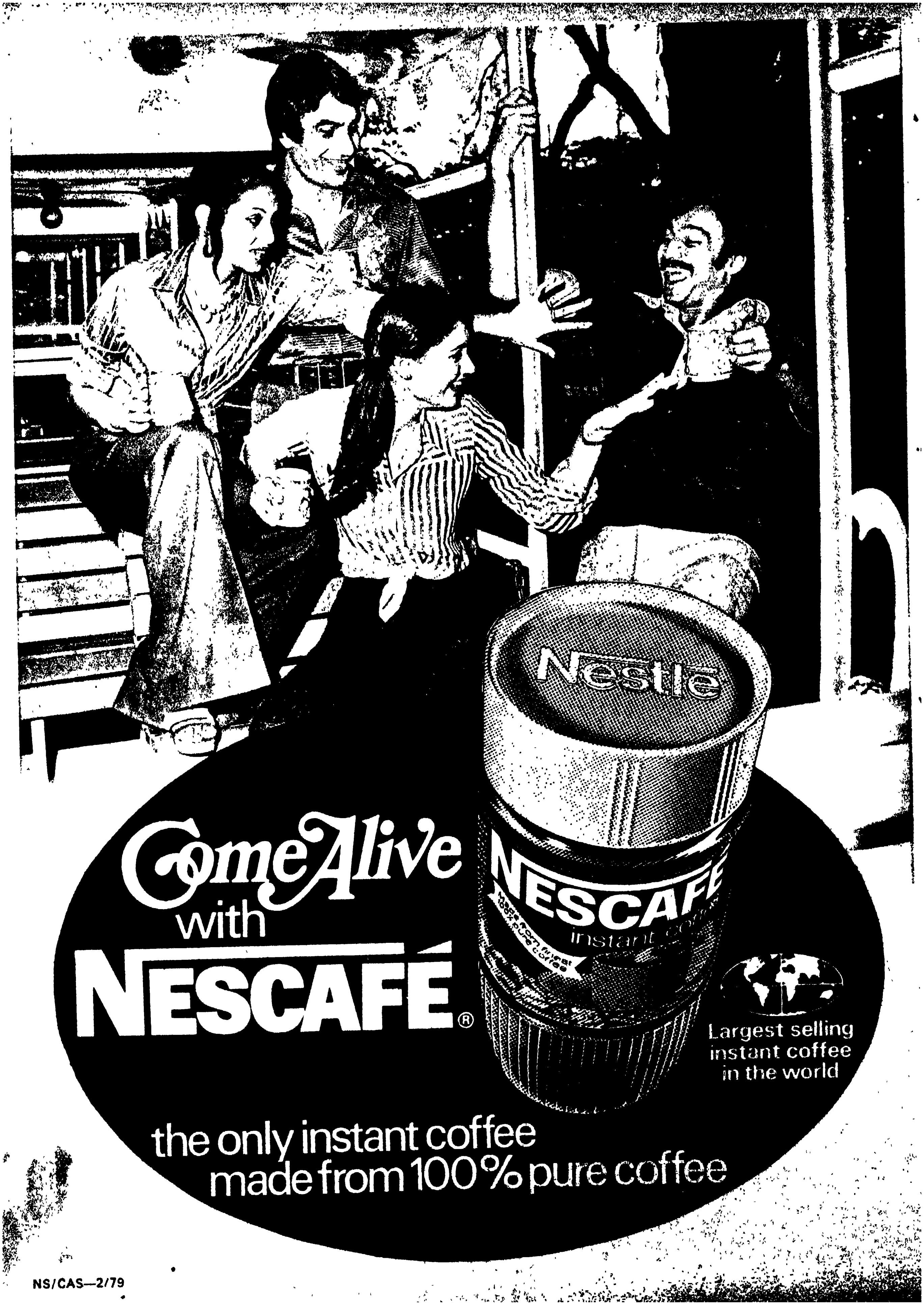
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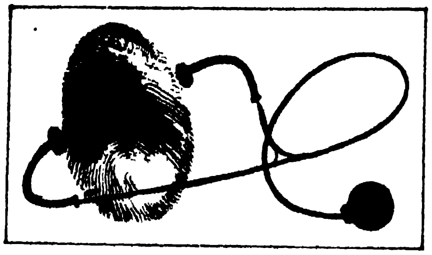
Science Today

June 1980 Vol 14 No 6

15 **How scientists read palms**
D. P. Mukherjee

Scientists are discovering links between lines of the palm and sole and heredity, certain diseases and racial characteristics

22 **New methods in dermatoglyphics**
B. V. Bhanu



29 **China plans to gear up science and technology**

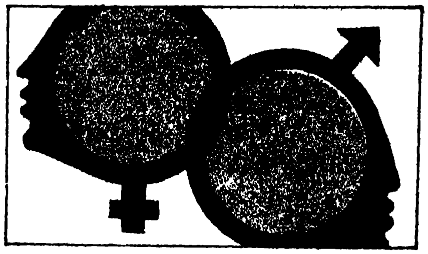
An ambitious eight-year programme that aims to reduce the time-lag between China and advanced nations

37 **Radiation protection in nuclear medicine**

Pushparaja
T. Subbaratnam
With the increasing use of nuclear medicine, radiation exposure will create problems

53 **Sexual differences in the brain**
Arthur P. Arnold

The male-female divide may be deeper than we think



62 **The method of science—6**
How does science work?

66 **Spotting the criminal**
Pritam P. Phatnani

Discerning eyes can espy the 'visiting card' the criminal invariably leaves

4 Letters
6 Viewpoints
8 Blurs and Bright Spots
11 Science Shapes Life
25 Round-up of Research
27 This World of Science!
27 ... and of Scientists
29 Another Window
35 Books
43 Ideas and Inventions
45 Quiz (Microbiology)
49 If ...
51 Awards and Appointments
61 Tell Us ...
65 You Too Can Do It
67 Brain Teasers

8 Technological detoxification

43 A handy letter-weighing device

49 If time ran backwards

61 Why are railway tracks dug up?

65 Musical dancing lights

Cover: Painting by
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Editor:
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Single copy: Rs. 2
Subscription: 1 year: Rs. 20;
2 years: Rs. 39; 3 years: Rs. 58.

Editorial queries are to be addressed to the Editor, SCIENCE TODAY, Times of India Building, Dr. D.N. Road, Bombay 400001. Unsolicited articles must carry adequate return postage.

Subscription queries and payments should be addressed to the Circulation Manager, SCIENCE TODAY, Times of India Building, Dr. D.N. Road, Bombay 400001.

Printed and published for the proprietors, Bennett, Coleman & Co., Ltd., by T.P. Pithavala at Usha Offset Printers Pvt. Ltd., 125, Govt. Industrial Estate, Kandivli, Bombay 400 067. General Manager: Dr Ram S. Tarneja. Branches: 7, Bahadurshah Zafar Marg, New Delhi 110 002; 139, Ashram Road, Ahmedabad 380 009; 105/7A, S.N. Banerjee Road, Calcutta 700 014. Offices at: 13/1, Government Place East, Calcutta 700 069; 63, Montieth Road, Egmore, Madras 600 008; 407-1, Tirath Bhavan, Quarter-gate, Pune 411 002; 26, Station Approach, Sudbury, Wembley, Middlesex, London, U.K. London Tel. 01-903-9696

EVOLUTION OF BEHAVIOUR

"THE EVOLUTION of Behaviour" by Madhav Gadgil (March 1980) is rather ambiguous and evasive on the question of whether or not human behaviour is genetically programmed. At places, it is hinted that this might be so, but scientific theory is built on precise statements, not insinuations. Hence, I would request the following clarifications:

1. What is the scope of the author's usage of the term "human behaviour"? Is the term being used in its wide sense? That is, does it include all aspects of human behaviour from prehistoric times to the present? Or is the term used in a narrower sense? If so, what are the limits of definition?
2. Does the author claim that "all human behaviour is genetically programmed"? (I hope that the reply will not be in terms of a stock statement like "human behaviour is to be understood in terms of both biology as well as environmental influences", which is so general as to be useless). Can Dr. Gadgil give definite examples of human behaviour which is (a) genetically programmed, (b) not genetically programmed? What is the basis for his separation?
3. What would be a scientific procedure to decide whether or not a particular kind of human behaviour is genetically programmed?
4. How do sociobiologists account for the differences in social practices between different human societies and cultures, for instance, between matrilineal and patrilineal inheritance? Are these genetic in origin?
5. Also, I would like a comment by Dr. Gadgil on Dr. Nanjundiah's statement made on the same subject (p. 30): ". in trying to build a theory of social behaviour based on sound biology, one cannot do worse at this stage than pick human beings as examples in support of the theory".

Vivek Monteiro
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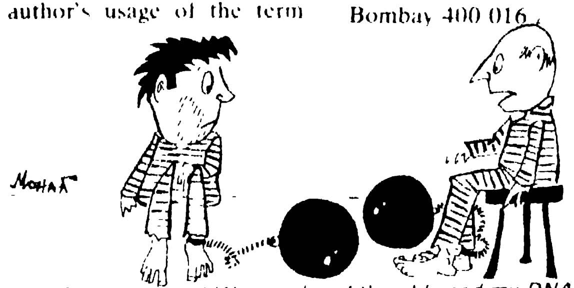

"The judge said '15 years' and then blamed my DNA."

CEMENT POLICY AND MINI-CEMENT PLANTS

ALTHOUGH the measures suggested by H. N. Banerjea (Viewpoints, January 1980) in increasing cement production are worth pursuing, one is not sure if mini-cement plants are ideal in the present circumstances. Mr Banerjea argues that mini-cement plants would help exploit small limestone reserves located in remote areas, save on packing and transport costs, generate more employment opportunities and have a shorter gestation period. But, though the cost per tonne of installed capacity is almost the same for both mini and large cement plants, the cost of production is much higher for mini plants. To compensate for this, the government has proposed to reduce the excise duty by 50 per cent, which works out to a subsidy of Rs. 34 per tonne. Before we decide to put up a large number of mini cement plants, we should consider the following factors.

The country has large deposits of limestone—2,800 million tonnes of proved, cement-grade deposits—and as stated by Mr. Banerjea, another 40,000 million tonnes of indicated and inferred deposits. Is it, therefore, necessary at this stage to exploit small deposits in remote areas incurring a much higher cost of production?

Since mini-cement plants will be put up mainly in the small scale sector, it would be difficult to ensure consistency in quality. A 1,200-tonne-per-day plant will employ 600 people, giving a productivity per person of two tonnes per day. Even if mini plants are three times as labour-intensive as the large ones, the proposed 50 per cent excise duty relief is equivalent to subsidising every additional job created through mini-cement plants by Rs. 34 per day. If emphasis is on employment generation, one can argue that six times or more additional jobs can be created with this amount of subsidy, say in rural developmental work.

The prompt supply of coal to the large cement plants is already a problem. With a number of mini plants in remote areas, how do we ensure supply of coal and coke breeze regularly in small quantities?

The policy of paying little to the producers has only helped create shortages due to lack of investment and has adversely affected consumers whose interest the government wanted to protect by pursuing this policy. Though the higher return announced recently has attracted more entrepreneurs, one may propose the following financial incentives besides what Mr. Banerjea has suggested.

Increase returns to new cement plants from 12 per cent post-tax to 15 per cent, on a net worth content of Rs. 230 per tonne of installed capacity, for the first five years of production; exempt new plants from payment of excise duty for the first two years; issue licences freely and permit automatic doubling of capacities, say, in a period of seven years; provide finances from a single financial institution nominated by the Industries Ministry; allow import of large cement plants freely to ensure early completion (assuming the foreign exchange component of a million-tonne plant at Rs. 18 crores, at the prevailing c i f price of imported cement which is over Rs. 600 per tonne, it works out to foreign exchange saved in just four months' production from the new plant); neutralise increased costs of inputs with retrospective effect and revise the price of Rs. 296 per tonne fixed for new plants in 1978.

A Reader

Mr Banerjea writes : *I agree, larger cement plants should receive more importance, but due share must be given to mini-cement plants also. Mini-cement plants are definitely viable, if all the financial incentives suggested by the reader for larger cement plants are given to mini-cement plants, and they are also given a rebate on excise duty and freed from the freight pool. The plants must be located in way-out underdeveloped areas.*

Post-tax returns on net worth may be increased from 12 per cent to 15 per cent, but I doubt if exemption of new cement plants from excise duty for the first two years will help. I also agree that, to avoid delay, a project should be helped by one financial institution and not by a panel of institutions.

Some 20 per cent of the large cement plants sanctioned should be imported. This would help in augmenting cement supplies earlier. I would even say that some mini-cement plants (mills, kilns, gear boxes and motors only) should be imported because some of the plants are finding it difficult to locate a suitable supplier. These may be done as turnkey jobs.

It is also true that the Cement Controller's office takes too long to raise the retention price when the cost of production goes up owing to the increased price of inputs. The controller's office should be given powers to scrutinise and increase the retention price, if necessary, once every quarter. This will help the producers prevent financial losses.

CONTROLLING A REMOTE CONTROL

I WOULD like to point out that anyone who assembles the IC whistle-tuned remote control (You Too Can Do It, March 1980) for his radio, TV, tape-recorder, or other audio equipment would be disappointed to find that the equipment (TV, radio, etc) switches itself off not long after it has been switched on. Any sound with a frequency around 1.5 kHz from the audio equipment is sensed by the remote control which switches off the gadget. I hope Mr. Borkar would find a remedy for this.

John Bastian
Thengazhithom
Mayyanad
Dist. Quilon, Kerala

Mr. Borkar writes: *The operation of the IC whistle-tuned remote control depends upon frequency, intensity, duration and direction of incident sound waves. Thus, the placement and the directional positioning of the IC whistle-tuned remote control with respect to the audio equipment is imparted to reduce the audio interference. Suitable positioning can easily be done by slight trial and error so that the device just doesn't operate with the interference but by the whistle.*

FRIENDLY KILLER WHALES

MANY READERS of my article (Dolphins, February 1980) have written asking about the friendliness of killer whales in captivity, stating that this belies the reputation attached to them. One of them has quoted the story attributed to a single 7.3 m killer whale that at a time ate 13 porpoises and 14 seals, and the tales of whales butting at ice floes so as to capsize them and devour men standing on the floes.

Being large carnivores, their food requirements are great. However, these oft-quoted stories are not accurate. It is based on a killer whale examined by D. F. Eschricht (Denmark) in 1861, and he clearly reported that he found "digested remains", some of which were just bone fragments. It is wrongly presumed that all these animals were eaten at once.

The animals have proved to be remarkably docile. A 7.3 m female caught in 1965 at Namu in British Columbia and brought to the Seattle oceanarium was very friendly. It not only allowed its trainer, Ted Griffth, to feed him 180 kg of salmon, without crushing him with its sharp teeth and powerful jaws, but even allowed the trainer to ride piggy back behind its huge dorsal fin.

There has been no authentic report of a man having been subsequently eaten. Being inquisitive, dolphins often poke their heads out of water to get a better view of objects on land. They sometimes scrape ship bottoms, not to capsize them but to rub their body to relieve itch.

The only exceptions, however, are wounded harpooned whales, especially sperm whales, who turn ferocious and ram the whale-boats with their heads or swipe them with their tails.

B. F. Chhapgar
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Colaba Causeway
Bombay 400 039.

CIGARETTE ADS

SCIENCE TODAY has always been demonstrating the hazards of cigarette smoking (Quiz, April 1980). Should SCIENCE TODAY then entertain advertisements on cigarettes or tobacco?

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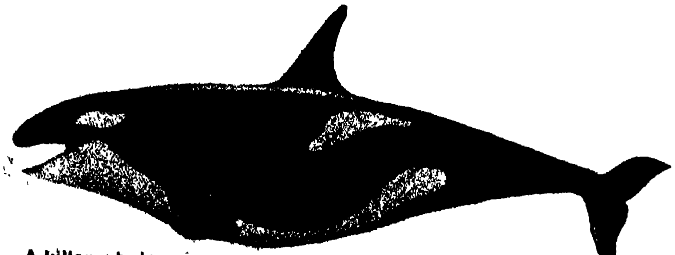
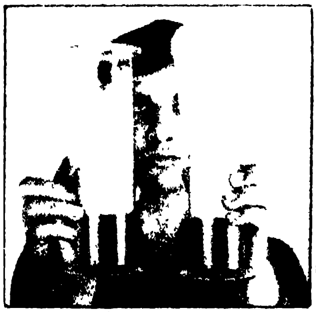


A killer whale

Foam sweet foam

When comparing one lather with another, shavers go by vague impressions and uneducated guesses Isn't there a way to measure lathering ability?



There is. It's known in the industry as the Ross Miles Foam Test. We pitted Lakmé Shaving Cream against two leading brands. Lakmé notched 25.8% and 15.4% higher readings for lather abundance. With a tighter concentration of bubbles, greater staying power, superior tenderising and lubricating action.

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Will rainfall over India increase?

A RAPIDLY increasing population demands ever increasing production of food. In the past, one of the important means of increasing food production in India has been to increase the area of land under cultivation. But this option has now reached near exhaustion. The only course now open is to increase the yield from existing farms. Luckily, there is still much potential for doing this.

The most important requisite for realising this potential is, of course, water, that is, irrigation. In the next two or three decades, there is going to be a rapid increase in development of irrigation facilities in India. A substantial part of the water that flows to the Bay of Bengal and the Arabian Sea will be held back, and spread over the croplands for meeting their consumptive demands. A large amount of water would thus be breathed out into the atmosphere, raising the humidity significantly. This is expected to engender substantial (perhaps drastic) change in the natural water balance over the country. In addition to the well-known, good and bad, ecological effects that follow from development of irrigation, it may bring some changes in local weather also. For example, with more area under irrigation crops, we may expect some reduction in severity of temperatures and dust storms. But a far more important change that may be expected to occur is the possibility of a substantial increase in regional rainfall, and the lengthening of the rainy season. Here, I wish to project this viewpoint.

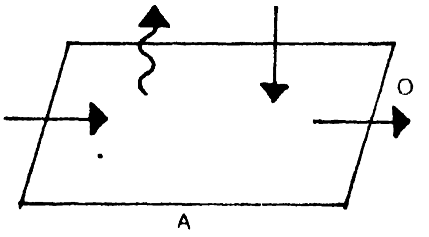
Forecasting the effects that may follow a man-made perturbation in atmospheric conditions is generally fraught with uncertainties; often, mutually opposing predictions can be made. Here, however, a relatively simple situation is considered, and the hypothesis should accordingly be more tenable. No trigger mechanism or regenerative process is proposed. A simple mass balance consideration, which is far more reliable, leads to the expectation of the proposed effect.

The situation is unique for India in many ways. It involves a large population, its ever increasing demand on food production, fertile land, warm weather, availability of plentiful water, and favourable physiography, particularly the existence of the Himalayas in the north.

During the monsoon, a very humid air mass, extending from the ground to an altitude of 5 to 6 km, pervades over the subcontinent. Much of the moisture in this air mass comes from the sea. But the contribution from local evapotranspiration over the subcontinent is not negligible; it amounts to about 20 per cent of the moisture influx from the sea. The natural evapotranspiration thus raises the average humidity of the prevalent air mass (away from the coastal areas) by 20 per cent. This is vital, for if it were not so, the average precipitation over the subcontinent would have been dismally poor because the precipitation-yielding synoptic situations would have been far fewer and weaker.

In contrast, let us consider the possibility of raising the average humidity of the prevalent air mass by about five per cent by artificial means. This should make precipitation-yielding situations even more frequent and intense. Thus there exists a distinct possibility of increasing the precipitation by making the already moist monsoon air mass still more humid. This, of course, assumes that no negative feedback processes are likely to set in; none is envisaged. Processes like vertical transport, entrainment of surrounding air in a rain cloud and other mechanisms important for rainfall should continue undiminished. The vital difference would be that the air masses involved would have a larger moisture content, which should therefore yield more rain.

The above proposition may also be looked at in the following way. Consider, for example, an area A where the moisture influx is I and the outflux is O. The precipitation, P, over the area is given by, $P \quad (I+E) - O$, where E is the evapotranspiration over the area.



During the dry season, precipitation is zero, and $I+E \quad O$, that is, the outgoing air mass takes away the evapotranspirated moisture with it. During the rainy season, however, $I+E$ is larger than O, and precipitation results. If we now artificially increase E, then, assuming that I and O remain unchanged, P should increase by as much as E does. Here, we are assuming that increase in local evapotranspiration does not affect moisture influx and outflux. Situations corresponding to both of the above possibilities can exist in India.

(i) During the dry season, both intensive and extensive irrigation will be resorted to. This will increase E drastically. That it must result in equivalent enhancement of precipitation somewhere or the other is obvious. But it is not certain that it will lead to criticality resulting in enhanced precipitation over India itself.

(ii) During the monsoon also, irrigation will be resorted to. This is necessary to make up for droughts and regional shortfalls. This should increase E substantially and should result in equivalent enhancement of rainfall over India itself. This assertion arises from the fact that during the monsoon the probability for rainfall is anyway quite high; any additional humidity should intensify the system. Further, it should assist some of the cloud situations, which now fizzle out, to attain criticality. This should apply particularly to the northern part of the country where there exists an effective trap for the moisture during the monsoon. The moist air enters north India at low levels, both from the Arabian Sea and the Bay of Bengal. The compensating exit of air takes place mainly at a high altitude, that is, by cold and comparatively dry air (ignoring a minor exit at 700m over north-west India). It would, therefore, seem that any artificial addition in evapotranspiration should result in an equivalent increase in precipitation on the average.

About 60 per cent of our rainwater is naturally evapotranspirated away. We can, therefore, avail of the remaining 40 per cent only (at the most) for irrigation. It is envisaged that during the next two or three decades it would be possible, and necessary, to utilise about 20 per cent of the rainwater for irrigation. About half of this, 10 per cent, is likely to be utilised for irrigation of *kharif* crops, that is, right during the monsoon itself when water is available in plenty, and can be used for irrigating the now expanding paddy cultivation and to make up for other regional shortfalls. The increase in evapotranspiration is expected to yield an equivalent (that is, 10 per cent) increase in precipitation. One hopes that there will be no more deforestation to offset the anticipated increase in evapotranspiration and consequent increase in rainfall.

But if there is, in fact, an increasing

trend, it is not likely to be uniform over the entire country; it may be quite intense in certain regions. For example, the development of the waters of Godavari, Krishna and other peninsular streams for irrigation should enhance precipitation over the central and eastern parts of the peninsula, and may also intensify the north-east monsoon. Similarly, development of irrigation in the Narmada, Tapi, Ganga and Sind valleys may result in a substantial increase in precipitation over the arid and semi-arid areas of Rajasthan. The development of some of these waters is already under way, others are ready to be taken up. Most of them are expected to be completed by the turn of the century. Since irrigation is likely to be developed selectively in areas receiving inadequate precipitation, the ensuing enhancements in precipitation are more likely to be intense in these areas, though not confined to them. Whether it will influence the variability of rainfall too is difficult to predict. The only thing that appears likely is that there should be a measurable increase in average precipitation, more pronounced in certain regions than in others.

The investment required to develop irrigation to the extent envisaged here will be colossal—in the range of 10^{12} rupees (one lakh crores), going by current trends of annual expenditure on irrigation. But it is an entirely feasible proposition and will be carried out over a period of two to three decades. This massive effort will alter the regional water balance substantially. It will raise the evapotranspiration by 25 to 30 per cent and atmospheric humidity by about five per cent, on an average, more in regions having irrigation and less elsewhere.

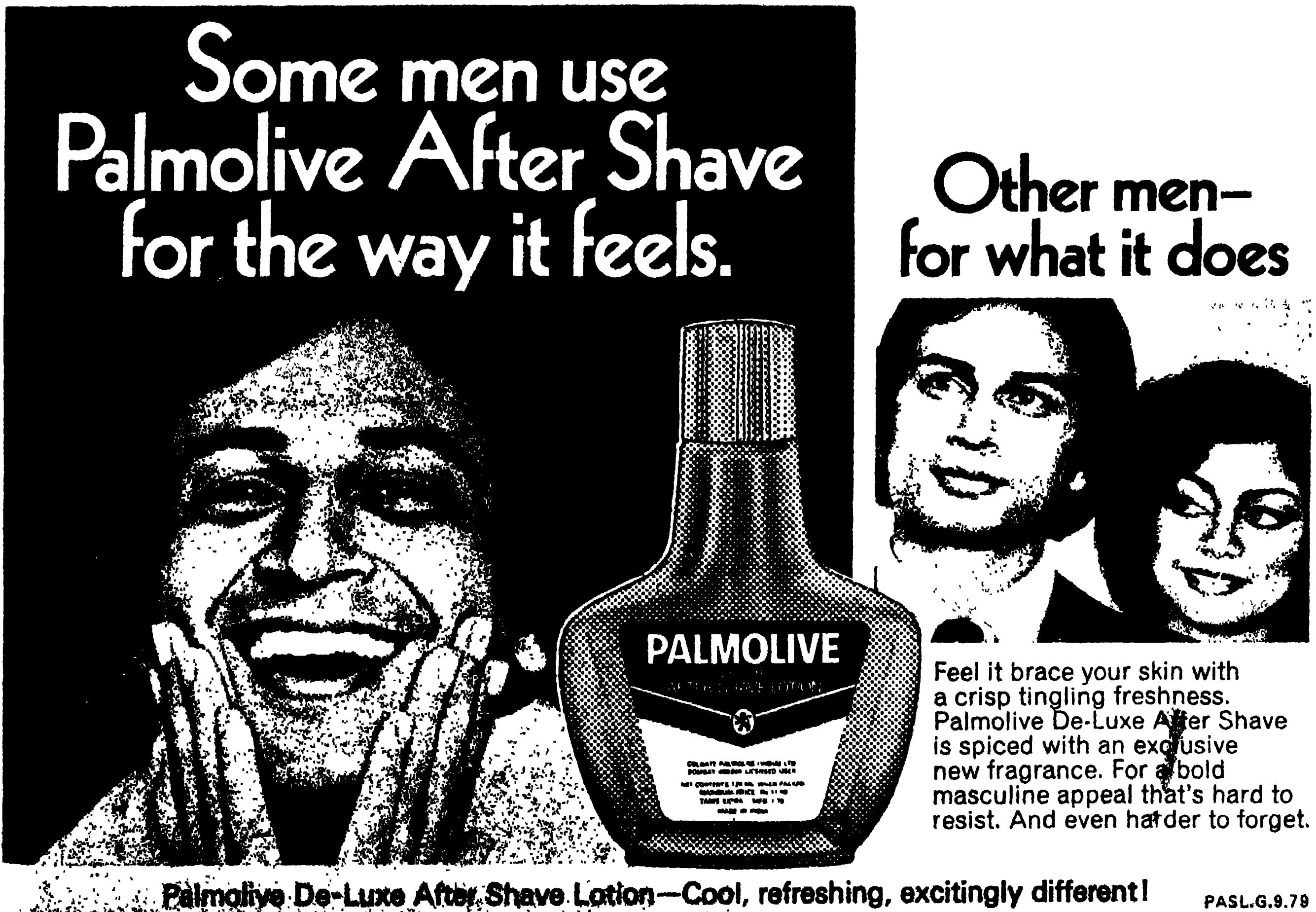
Why the fuss?

The above hypothesis, when looked at from the angle of pure science, is indeed poor in as much as both the cause and the predicted effect lie in the future (about 20 years away). But we are talking here about the most valuable resource, rainfall and the possibility of a substantial increase in this resource. Its sheer importance provides justification to open it for discussion. If it does turn out to be right, the gains can be tremendous. The rainfed crops in currently marginal areas will acquire reliability. A couple of showers towards the maturity of a crop can mean a lot. There is, however, no question of planning on the basis as yet. We should go on developing irrigation with the usual considerations without worrying much about how it may affect the local weather or rainfall. But when a definite trend becomes visible, new considerations would be warranted. It would, therefore, be worthwhile to keep a watch on the emerging trend. If there is no increase in rainfall, we have lost nothing. But we must seek an explanation for that. On the other hand, if the expected effects materialise, we may think of sophistication in developing further irrigation, that is, artificial evepotranspiration.

A further possibility, though in the realm of pure speculation at present, lies in exploring whether it is feasible to break the low-level atmospheric inversion over the arid areas of Rajasthan by this method or by combining it with some other equally powerful (and feasible) method, thus making rainfall more probable there. Such a target may become attainable as we think and understand more about it.

RAMA

Prof Rama is with the Hydrology Group, Tata Institute of Fundamental Research, Bombay.



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Blurs and Bright Spots

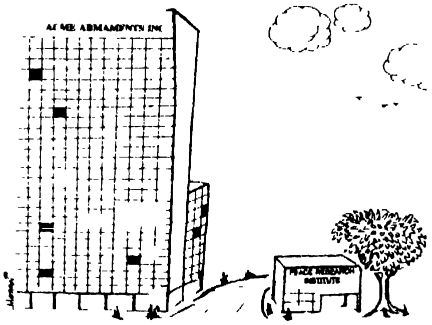
Technological detoxification

In another place—and, it now seems to me, another time—I wrote that "much of what we today regard as good and useful, as well as much of what we would call knowledge and wisdom, we owe to science." I then added: "But science may also be seen as an addictive drug. Not only has our unbounded feeding on science caused us to become dependent on it, but, as happens with many other drugs taken in increasing dosages, science has been gradually converted into a slow-acting poison." Reading these words years after I wrote them, I am now surprised that I didn't take the next obvious step—that is, to talk about our intoxication with science and technology.

The word "intoxication," comes from the Greek "toxicon," which means arrow poison. According to the dictionary, to be intoxicated is to ingest a poison in a dosage sufficient "to excite or stupefy to a point where physical and mental control is markedly diminished." Significantly, the dictionary gives an alternative definition, namely, that to intoxicate is "to excite or elate to the point of enthusiasm or frenzy."

Who can deny that it is precisely excitement, enthusiasm, and especially frenzy that characterise modern western society's involvement with science and technology? When one recalls the manner in which the United States committed itself to putting a man on the moon, to name only one example, the characterisations just mentioned leap to mind. It was said that the project would lead to the discovery of crucial secrets which, once unlocked, would lead to the deepest insights into the origin of the universe—that it was, in other words, a search for knowledge for its own sake. In fact, the excitement it generated—which President Kennedy's speech was intended to generate—and the enthusiasm shown by the American public and the technical community had much more to do with the "space race" than with any scientific goals. Moreover, a truly scientific project would have been allowed to set its own pace, allowing thought and reflection to determine intermediate goals and strategies. But the president himself set the frenzied pace when he announced that the intended result would be achieved "within this decade". Another American president, Richard Nixon, greeted astronauts returning from the moon with the words that this was the most *exciting* moment in his life—as if the purpose of this enormously expensive and dangerous undertaking had been to provide excitement for the people of the United States.

Each day more than a billion dollars are spent worldwide on scientifically refined instruments of death; the United States adds three hydrogen bomb warheads to its arsenal; and in the best-equipped research laboratories of the world young men and women exercise their god-given intelligence and ingenuity to bring the targeting mechanisms of missiles ever closer to perfection. And every now and then America's so-called first lady *christens*—just think what that word means!—a submarine, while her husband boasts that we can wipe out life (though not necessarily property) in every major city in the Soviet Union within a few minutes. Clinical insanity! Utter madness! Who can deny that we are rapidly losing—have perhaps already lost—physical and mental control over our society?



One can be intoxicated—that is, affected by the ingestion of a toxin—without being addicted to that toxin. We can speak of addiction only when the affected organism has undergone physiological changes that cause it to be *dependent* on the toxin. Anyone can get drunk, but not every drunk is an alcoholic. I assert that our society has, in fact, become organically-modified by our massive ingestion of the worst fruits of our science and technology. Our loss of control is not momentary, nor is what afflicts us merely a sudden compulsion. The signs of addiction are everywhere around us: massively distorted perceptions of reality abound, and we euphorically embrace every technological fix proffered as a "solution" to every human "problem." The most visible monuments to our world view are our preoccupation with speed, power, and quantity, and—above all—the colossal hubris of much of our scientific community. (Just recall that the "blame" for the recent misadventure of the Skylab satellite was pinned on the misbehaviour of the sun—too many flares—not on any miscalculation on the part of scientists!) These conditions reflect organic lesions in our society—they are too deep and they have been with us too long to permit us to dismiss them as temporary aberrations.

The toxin that has invaded us, as seen from the perspective of an information scientist, is fundamentally *abstraction*. To abstract means to draw away from. Science, to function at all, must practice abstraction in that it must necessarily simplify and deal with idealised models—in other words, draw away from reality. And science, idealisation, and abstraction are good and useful in proper dosages, when mediated by wisdom gained from many other perspectives. But, beginning roughly at the time of Bacon's observation that knowledge is power, we began to confuse the abstract with the real and then forgot how to make the distinction at all. Our increasing lack of contact with reality is illustrated by the march of abstraction with respect to the products of human labour and to human labour itself. People once traded their labour directly for goods. Then money was introduced as an abstract quantification of human labour. Then cheques and other financial instruments became abstractions for money. Now we are approaching the so-called cashless society, in which electrons racing around computers out of reach of human senses become abstractions for financial instruments. An observer from another planet will see people labouring to optimise the paths of electron streams flowing on their behalf in computers unseen and incomprehensible.

Perhaps the most pervasive evidence of the phenomenon I am trying to describe is our substitution of peoples' images for their real persons. This applies not only to individuals—candidates for political offices and other so-called celebrities, for example—but to entire populations. America's war in Vietnam was fought largely to impress various "audiences"—the word comes straight from the Pentagon and from the State Department. The *image* of the United States was at stake, not the lives of real people. An American secretary of "defence" (I put that last word in quotes because it is an Orwellian lie), Melvin Laird, once as [illegible] hydrogen bombs were not weapons of destruction but "bargaining chips," of which America had to have a great many so that she could "disarm from a position of strength". This is a logical extension of the well-established military principle that often villages have to be destroyed in order to save them.

Nothing is a more concrete or dangerous manifestation of our confusion of the abstract with the real than the ongoing international arms race. It is perhaps merely a grim joke, but I think it points up a tragic reality, that the foundation of the so-called defence policy of the NATO alliance is officially called MAD, an acronym for "mutual assured destruction". We must withdraw from the myth that ever more numerous powerful weapons of mass destruction offer security to the people of the world. I plead that we stop adding to our already enormous nuclear arsenal—that we begin to *reverse*, not merely to "control," the arms race. My personal position is that the United States ought to begin that process unilaterally.

At still another level, the transformation of reality into imagery serves to stupefy the collective consciousness of the people. I have in mind the corruption of everyday language, hence of the creative imagi[illegible] of speakers of everyday language, through the illegitimate raising of science-based metaphors to the status of common-sense truths. It is, for example, commonplace to hear of people being programmed. In this way the notion of an abstract machine—one that fascinates the general public almost to the point of hypnotism—becomes that of a human being. And once we accept that human beings are machines, merely symbol manipulators and information processors, then the final step—namely, the deliberate initiation of a programme to alter the course of biological evolution in such a way that the human species is replaced by "silicon-based intelligence"—can be announced by the most eminent scientists—for example, Dr. Robert Jastrow, head of NASA's Goddard Space Flight Center. This can be done without altering anyone that what is being talked about is the death of the human species.

It seems to me obvious that what is now needed is an energetic programme—at least for the Western world—of technological detoxification. We must first admit that we are intoxicated with science and technology, that we are deeply committed to a Faustian bargain that is rapidly killing us spiritually and will soon kill us physically. And we must [illegible] courage and the will to believe that we can recover. We must decide affirmatively to halt the Orwellian corruption of language and gradually wrest ourselves away from the framework of abstractions we have erected. We must live one day at a time in the *real* world, a world peopled by genuine human beings, not images, a world in which word and deed are inherently valued, not the engineered applause of some abstract audience.

As a computer scientsist, I am keenly aware of the central role the computer plays in this respect. The computer in our society is in large part a solution in search of problems. The mentality that breeds and nourishes this condition converts human and political problems to technical problems and then proposes technical solutions. One effect of this conversion, not always unintended, is that it distracts attention from real conflicts.

We must begin to assess our situation, and if our assessment reveals technological problems, only then bring our technology to bear.

JOSEPH WEIZENBAUM

Joseph Weisenbaum is professor of electrical engineering and computer science at the Massachusetts Institute of Technology, USA. This article was originally prepared for the World Council of Churches 1979 Conference on Faith, Science and Future

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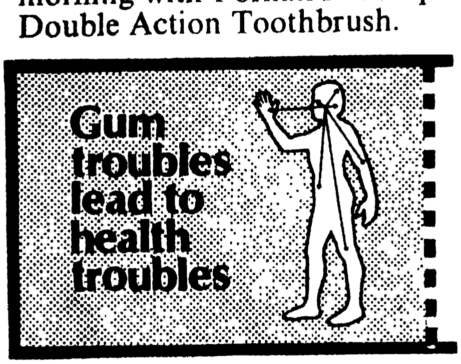
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Science Shapes Life

ALUMINIUM CAUSES SENILITY?

Aluminium is one of the most used metals in day-to-day life. But so far, no biological role has been assigned to it. On the other hand, it has been implicated as a neurotoxin; long-term hemodialysis, it has been found, leads to dementia and in such individuals aluminium levels in the brain are abnormally high. A similar condition is also noticed in Down's syndrome patients.

Two US researchers, P. Perl of the University of Vermont College of Medicine, Burlington, and A. R. Brody of the National Institute of Environmental Health Science, North Carolina, have found high levels of aluminium in the neurofibrillary tangles of both senile and normally aged brains. It is also known that senile brains are rich in neurofibrillary tangles. This indicates aluminium is somehow linked with senility. Normal neurons in both groups contain almost no aluminium.

MICROBES TO DISSOLVE CLOTS

Blood clots are a problem for heart patients; they can choke a vital blood vessel and cause death. The clots can be dissolved by an enzyme called urokinase. Urokinase, at present, is extracted either from human urine or cultured human kidney cells. The method using cultured cells, besides being expensive, is complicated. The enzyme is formed along with other proteins from which it has to be isolated.

Now scientists at an American pharmaceutical company have used genetic engineering techniques to synthesise the enzyme. They extracted messenger RNA from human kidney cells using an enzyme called reverse transcriptase. From this they built up the DNA which contains the gene that codes for urokinase and introduced it into *Escherichia coli.* The bacterium churned out the alien protein.

The genetic engineers are now planning to induce the bug to make more of the enzyme and in a purer form.

MOON DUST ON EARTH

Several times in the history of the solar system, supernovas have occurred near it. According to British astronomers, such an event could waft lunar material to the earth. Describing this extraterrestrial erosion, M. Rudaman and J.W. Truran of the Institute of Astronomy, Cambridge University, England, say that certain kinds of supernova are preceded by intense blasts of gamma rays. Such a blast would evaporate surface material from an atmosphereless body like the moon. Some of the vaporised lunar material would escape the moon's gravity and drift to the earth. How could we identify moon dust? Unusual iridium concentrations in terrestrial sediments would be the tell-tale sign. Such layers have been found in Gubbio in Italy (SCIENCE TODAY, February 1980, p 17).

There is one drawback to the theory; so far, no gamma ray burst has been observed before a supernova occurs. In fact, detecting one would be a matter of chance since the supernova becomes visible only after the burst has passed. However, there is some evidence that gamma rays have tampered with the earth's upper atmosphere.

Gamma rays reaching the upper atmosphere of the earth would increase nitric oxide production and ozone destruction which in turn would lead to an increase in nitrogen trioxide. Unusually high amounts of negative nitrogen trioxide ions have been found in layers of antarctic ice whose dates of formation correspond to the known supernova. This lends support to the new theory; probably tonnes of lunar material had reached the earth much before lunar explorations began.

SMALLPOX, THE BOGEY

For anyone who reports a case of smallpox, WHO promises a monetary reward. Smallpox, in India, died in 1975. The last known case in the world was in Somalia in October 1977. Yet no one is sure that we have seen the last of the disease. There have been threats of a fresh outbreak now and again (SCIENCE TODAY, October 1978, p 7).

Recently, on 23 April, a case of smallpox was reported from Italy. The victim, a 32-year-old engineer who had just returned from Indonesia, had been originally diagnosed by his clinician as having chicken pox, stated the regional health authority for Lombardy. When samples were sent to the laboratory, it turned out that the man had contracted smallpox.

This created panic. WHO sent a doctor from Geneva. Across the Atlantic, in the US, people planning to visit Italy frantically called the Center for Disease Control (CDC) in Altanta for more information. Meanwhile, the disease subsided and samples sent to Paris showed that it was chicken pox, after all.

The WHO smallpox eradication programme is based on the premise that there is no natural reservoir for the disease from where it can erupt time and again. But is this premise sound? *Nature* (8 May 1980) reports that Russian studies have shown that in the passage of monkeypox virus through hamsters and in the pock appearing on the chorioallantoic membranes infected with monkeypox, there sometimes emerged a virus which could not be distinguished from the smallpox virus in laboratory tests. Monkeypox and smallpox viruses are closely related. Yet monkeypox rarely affects man. And when it does, it is easily distinguishable and is not transmitted from person to person. However, the virologists do not rule out the possibility of smallpox virus emerging from monkeypox virus. There has also been an instance of the disease resurrecting when a smallpox victim's grave was dug up in Britain (SCIENCE TODAY, October 1978, p 7). Several people in the vicinity got the disease and died.

WHEN THE BAMBOO FLOWERS...

...in several parts of India, it is said to foreshadow a famine. The enormous amount of seed the bamboos produce pushes up the rodent population and when the pests run out of bamboo rice they turn to food crops.

Bamboos generally propagate asexually. But once in their life, most bamboo species flower, produce large amounts of seed and die. Generally, all bamboos of a given species flower simultaneously. As a result, there will be no fresh stands of this giant grass till the seeds take root. In China, the recent flowering of a bamboo in Sichuan province is starving the giant pandas by depriving them of their sole diet. Several of these 'Teddy bears' have died already. And the future of the remaining ones looks bleak.

Earlier, bamboo forests were more extensive. So when plants of one region flowered and died, the pandas just had to shift their homes. Nowadays, the forests are more restricted and also all plants in a forest might be the asexual progeny of just one seed, and so they'd set seed simultaneously. Pandas are fewer now, anyway.

THE MOTHER AND HER NEWBORN

It is not always love at first sight for the new mother as she holds her newborn baby. Many mothers feel detached and indifferent. According to a survey at the University College Hospital, London, England, 40 per cent of the women felt detachment when they first held their baby. Though a majority took an instant liking, a good number also experienced mixed feelings.

None of these are abnormal feelings, nor do they interfere with upbringing; for example, indifference does not affect breast feeding. It was notable that painful labour led more often to indifference. Women who had a minor operation during (amniotomy) or before labour also responded with indifference; in the case of forceps and caesarian deliveries, however, no indifference was observed. Indifference occasionally lasted for nearly a year but positive dislike never exceeded six months The feeling, therefore, need not cause concern.

What could be the other reasons for the lack of affection? According to scientists, modern obstetric practices may be partly responsible, but there can be biological reasons too. One is that if the child dies, the grief would be less. Affection may, therefore, be withheld till the baby's survival chances are better.

WATER AND HEART DISEASE — THE HARD LINK

Some years ago, it was found that the incidence of cardiovascular deaths was 50 per cent higher in soft water areas than in hard water areas. Scientists had then attributed the higher death rate to the corrosiveness and the capacity of soft water to dissolve heavy metals, especially cadmium (SCIENCE TODAY, November 1974, p 9).

Following this finding a few English towns had even begun hardening their water with calcium and magnesium. Well, they had done the right thing. According to P.D.M.V. Turlapaty and B. M. Altura of the State University of New York Downstate Medical Center, Brooklyn, USA, it is the low levels of magnesium that caused the deaths.

The researchers incubated isolated dog arteries in a solution and exposed them to various concentrations of magnesium. Earlier studies had shown that heart muscles of sudden death victims contained lower than normal levels of magnesium. Turlapaty and Altura found that lower than normal levels of magnesium increased the artery tone, whereas high levels decreased the tone. Also, a lowered magnesium level made the artery more responsive to body chemicals. Thus hypomagnesemia, they conclude, could produce progressive vasoconstriction resulting in coronary arterial spasm leading to sudden death.

STONES STOP SMOKING

If you are hooked to the fag and want to give up, all you need to do is pick up a stone. Holland's Public Health and Smoking Foundation is selling what it calls the "Stop Stone" for about Rs 12 through a chain restaurant.

The foundation classifies smokers into two categories: the oral types and the tactile types. The stop stone works only for the tactile types who always want to do something with their hands. The stone keeps their hand busy so that they don't have to reach for a cigarette.

The trick was discovered by one such fiddler — an archaeologist. At one prehistoric archaeological burial site, this elderly gentleman picked up a stone that fascinated him because of its unusual shape. He began to carry it with him all the time, and in time this inveterate smoker had forgotten his fags. The 'stop stone' which the Foundation is selling is modelled on the one that the archaeologist found. The only thing it has probably not taken into consideration is, will all fiddlers find this shape so fascinating as to keep fondling it all the time?

WHO MADE ZIMBABWE?

The native blacks, of course. Zimbabwes are ancient settlements spread across Mozambique and Zimbabwe in southern Africa. The newly independent Zimbabwe takes its name from the Great Zimbabwe which, at its growth peak, is estimated to have had a population of 10,000. It was probably the largest city in southern Africa.

At the centre of each settlement is a stone-walled structure. Carbon dating puts the age of these settlements around 1000 years. From this, it is logical to assume that the local blacks built the zimbabwes. But for some reason the white settlers did not want to accept the fact. They made it out that the stone-walled structures were Egyptian temples built by the Queen of Sheba. And the Portuguese simply attributed them to the mythical Lusitanians.

When much better carbon dates were established in the late 1960s and early 1970s, the Rhodesian government gagged the information. Dates were removed from all museum displays. New guide books were not allowed to print the dates and an old one containing the dates was kept out of print. The Queen of Sheba still ruled supreme.

However, after Mozambique became independent in June 1975, a zimbabwe at Manykeni was studied. Results showed that it was occupied from 1250 to 1750 and the two-metre high stone walls were built around 1450. The archaeological work was done by a Mozambican and two British archaeologists.

The British archaeologists, Peter Garlake and Paul Sinclair, who had earlier worked on the Great Zimbabwe, had quit because they were not allowed to publish their findings. The Manykeni site, excavated by the natives under the supervision of the archaeologists, has been put up for exhibition; it gives a glimpse of life before the foreigners made the scene

TWINS HELP HEREDITY STUDIES

Scientists have often debated whether it is nature (one's inherited qualities) or nurture (one's environment) that shapes an individual's psychological traits. So far, the nurturists have been leading But now, the other theory that genes too play a significant role seems to be gaining ground. And this is mainly due to the study of identical twins reared apart; identical twins, as the term indicates, are genetically identical.

At the University of Minnesota, USA, a team of psychologists, headed by Thomas Bouchard, is conducting exhaustive studies on separated identical twins. Bouchard expected more differences and less similarities than was found. The similarities found were remarkable: similar mannerisms, physiological complaints, fears and phobias, way of dressing and sometimes, even similar vocation. For example, there were two sisters who wore seven rings each, two bracelets on one hand and a bracelet and watch on the other. In another case, two sisters were both afraid of water and both tended to sit with their backs to the sea while on the beach. And then there is an interesting case of two brothers—both incidentally had the first name, Jim. Both had married and divorced, and their first wives were both named Linda. Both men's second wives again had the same name—Betty. Well, this could be coincidence but the similarities didn't end there. One named his son James Alan and the other James Allan. Both men had worked as part-time deputy sheriffs.

Both had dogs named Toy, both drove Chevrolets, liked mechanical drawing and carpentry, chewed their nails down to the nubs and vacationed in Florida. Besides, they had similar smoking and drinking habits. And one could go on almost endlessly about the similarity of the blood pressure, weight gain, migrane and medical problems. However, there were some differences too. But despite different emotional environment, their psychological inventories were strikingly similar.

Even in cases where twins were reared in entirely different cultural settings there was a strong resemblance between them.

Earlier, IQ tests and personality questionnaires were the sole basis of such investigations. Nowadays, the tests are more elaborate. Apart from psychological tests, there are several written tests and interviews which last for six days, the twins answer about 15,000 queries on their family background, childhood, personality traits, interests, hobbies aesthetic judgement, colour choice and many others. They also undergo IQ tests and a detailed report is made of their medical histories including diet, smoking and exercise.

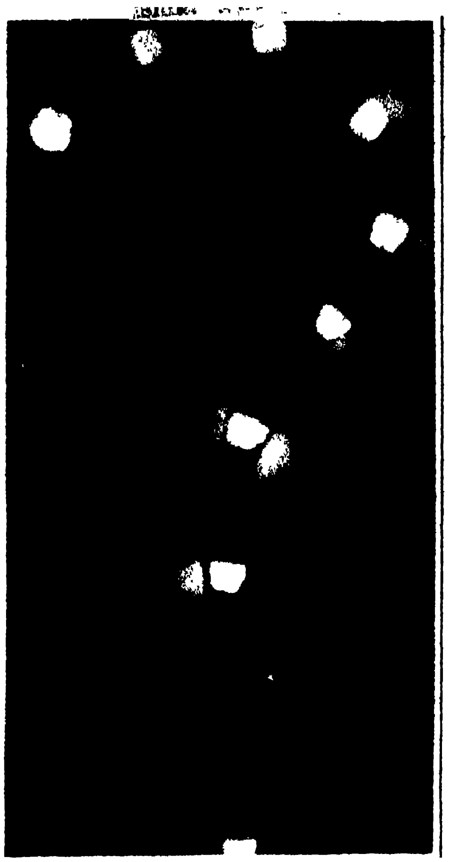
One explanation for similar tastes is illustrated by the 7-ringed sisters. The fondness for rings is not genetic, according to psychologist David Lykken, who studies brainwaves of twins, but probably pretty hands—which are the result of certain genes—might lead to beringedness.

FIREFLIES EXPLAIN PESTICIDE ACTION

Chlordimeform is a formamidine pesticide. Formamidines, a new class of pest control agents, do not kill their victims, but instead cause abnormal behaviour in them. This class of compounds is aimed at lepidoptera (butterflies and moths), other insects, ticks and mites. The treated pests may stop eating, disperse from their host plants, lose foothold from their animal hosts or even exhibit strange mating behaviour.

How these compounds act has not been clearly understood. Various explanations have been put forward—mitochondrial uncoupling, inhibition of the enzyme monoamine oxidase, local anaesthetic effects and blockage of neuromuscular transmission. But none of these are satisfactory.

Recently, R. M. Hollingworth and L. L. Murdock, Purdue University, Indiana, USA, used the compound on fireflies of the species *Photinus pyralis*. Chlordimeform and its metabolites caused the fireflies to light up even at doses as low as five nanograms. From this, one may conclude that their toxicity stems from their action on nerves which use octopamine as a transmitter. Octopamine is thought to have multiple actions as a neurohormone and neurotransmitter similar to the action of epinephrine in vertebrates, but their role in the insect central nervous system is not clear. The studies showed that the pesticide acts as an octopamine agonist. This indicates a new biochemical site for pesticidal action.

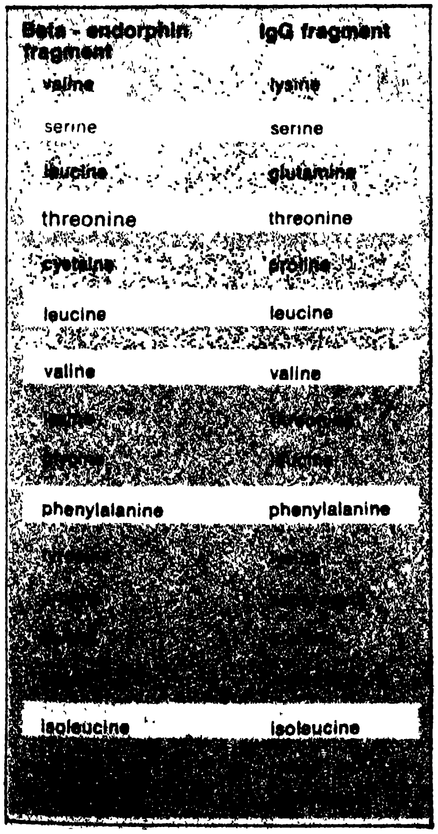


Treatment with chlordimeform, a formamidine pesticide, causes the light organ of the firefly *Photinus pyralis* to light up. Shown above are nine insects treated with one microgram of the compound and an untreated insect which remained unlit

HORMONE TESTS CAN BE MISLEADING

Hormones are secreted in very minute quantities which makes their chemical detection almost impossible. Scientists, therefore, rely on immunological tests. Immunological methods involve using known antibodies to fish out the hormone. When a foreign protein is introduced into an animal, its body reacts to produce specific antibodies that bind the protein. Similarly, using known antibodies, scientists were able to identify unknown samples.

Now Nobel laureate Roger Guilleman has found a serious flaw with this technique. Guilleman, who is known for his identification of brain hormones, and his colleagues at the Salk Institute, California, USA, have found that certain proteins from the human placenta had been wrongly identified by using the standard techniques. The researchers who isolated the placenta proteins identified them as beta-endorphin and ACTH (adenocorticotropic hormone).



Beta - endorphin fragment	IgG fragment
valine	lysine
serine	serine
leucine	glutamine
threonine	threonine
cysteine	proline
leucine	leucine
valine	valine
[illegible]	[illegible]
[illegible]	[illegible]
phenylalanine	phenylalanine
[illegible]	[illegible]
isoleucine	isoleucine

Even in these small fragments of the two proteins there are as many as six overlapping points. Antibodies meant to, or rather presumed to, identify beta-endorphin coupled as readily with ACTH

Guilleman and his colleagues repeated the experiment. From nearly 2,500 kg of starting material—wastes from an industrial plant that processed human placenta—they obtained about a quarter gram of the protein.

The Salk scientists had been on the trail of the beta-endorphin-precursor molecule which, it was thought, encompassed beta-endorphin and ACTH The protein they obtained from the human placenta reacted positively in antibody tests. In fact, antibody tests were used to monitor the precursor molecules all through the purification process, and finally it was even used to isolate it.

The compound, wrongly identified at first, was found to be immunoglobulin G (IgG) A comparison even of fragments of beta-endorphin and the IgG chain shows how six amino acids occupy the same position in the two proteins.

For the past 20 years, immunological techniques have been used as standard techniques for the detection of proteins. It has been thought to be the most powerful and sensitive method. Guilleman's finding is quite upsetting. Probably many more errors will be discovered when scientists retrace their steps in view of the new discovery.

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How scientists read palms

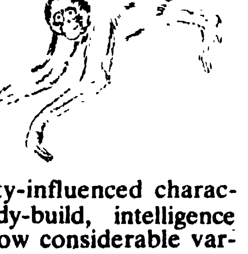
D. P. Mukherjee

Palmistry, with all its lines of head, heart, life, fate and so on, is a popular sport. Scientists find that they too have a lot to read on palms.

TO MANY people who like to believe that their future is inscribed on their palms in the form of the thick lines of hand, heart, fate, life and so on, it will come as a let-down to know that these lines, beloved of palmists, are mere anatomical creases: when the hand is flexed, the thick skin of the palm breaks up along a number of lines to produce creases.

If you look closely at the palms of your hands or the soles of your feet—preferably with a magnifying lens—you will notice minute ridges and grooves, too. In recent years, these tiny grooves and ridges on the palms, which in the form of fingerprints have for long been indispensable in a person's identification, specially in crime detection, have aroused the interest of anthropologists and medical geneticists. These skin ridges show a lot of consistency in ethnic variations; and the correlation of specific ridge patterns with certain genetic disorders has held out the promise of their utilisation in genetic screening before birth.

Such corrugations are also found on the palms and soles of other primates. Like treads of an automobile tyre, they help to secure a firm grip. Such anti-slip surfaces occur even on the grasping tails of certain monkeys, like the howler monkey and the spider monkey. The ridges and furrows also enhance the sense of touch.



Ridges on a spider monkey's tail

Many heredity-influenced characteristics like body-build, intelligence and diseases show considerable variation. Obviously they are controlled by several genes and are also greatly influenced by the environment. Dermal ridges, on the other hand, are formed in early prenatal life and are immutable: they constitute the best example of quantitative differences which are almost unaffected by the environment.

These fine ridges and the patterns they form aroused scientific interest about 300 years ago, and from this evolved a branch of anthropology called dermatoglyphics. The name dermatoglyphics derives from Greek *dermis* meaning skin and *glyphe* meaning carving.

The earliest study of ridge patterns appears to have been made in the Orient. Ancient Indian literature on palmistry describes figures of *chakra* (wheel), *sankha* (conch shell) and *padma* (lotus) on human palms, soles, fingers and toes (see photo). In the 17th century, western anatomists noted the abundance of large pores of sweat glands on the crests of the ridges and also studied the arrangements of ridges on fingers and palms. In 1923, a Bohemian professor of physiology, Johannes Evangelist Purkinje, proposed a nine-fold classification of the *rugae* (ridges) and *sulci* (furrows). But the fundamental knowledge of the structure, function and development of the skin ridges was established only towards the end of the last century. The basic methods and principles of dermatoglyphic studies were laid down in 1892 by Sir Francis Galton, a cousin of Charles Darwin.

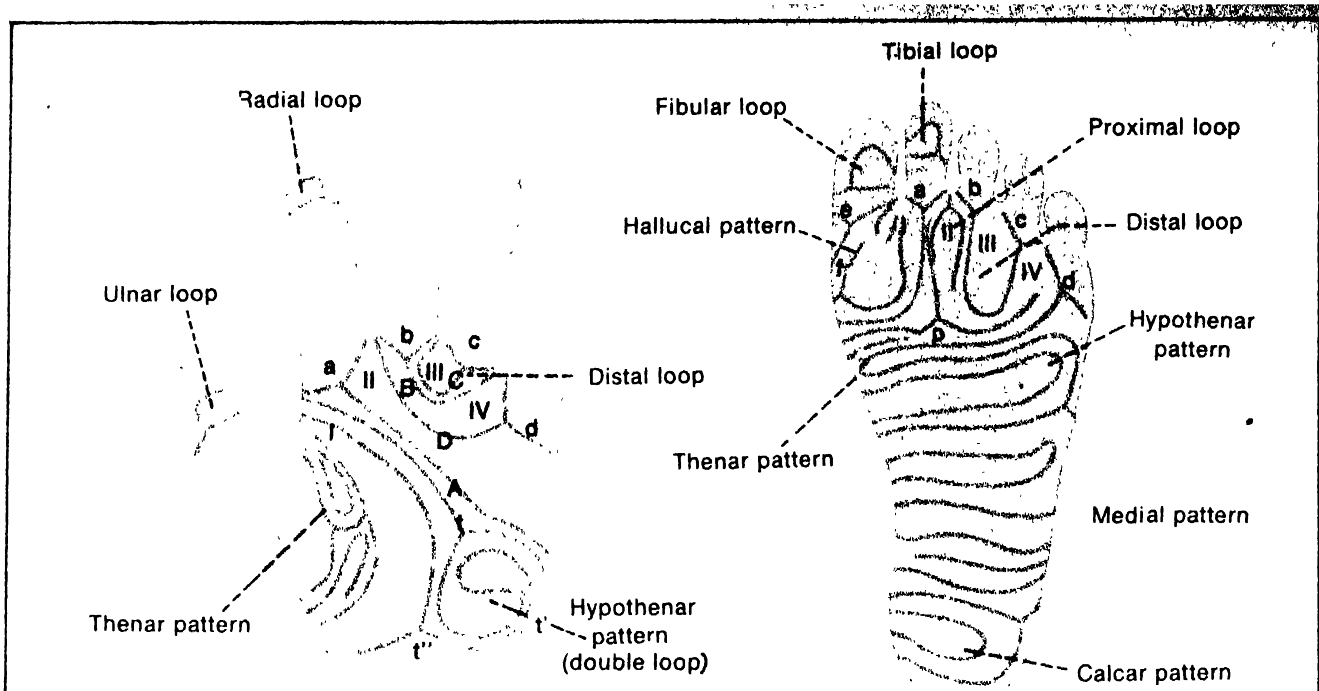
Sir William Herschel, the administrator of Hooghly district of Bengal, reported to *Nature* in 1880 that his own fingerprints had not changed for 20 years. On the advice of the local pandits he had taken fingerprints of pensioners for identification. Thus when Henry Faulds, a member of a Scottish medical mission in Japan, wrote to him about fingerprints on ancient potsherds, Herschel wrote back about the utility of fingerprints in identification and how prints left by criminals helped in tracking them. Earlier in 1878, Faulds also had written to Darwin about the possibility of tracing human evolution through fingerprints and Darwin had forwarded the letter to Galton. Galton worked on Herschel's prints from Bengal and also collected fingerprints in London. He established the unique characteristics of single ridges which he called the minutae, and demonstrated the rare chance of recurrence of

any specific features. Galton's method of counting ridges on loops to further classify them were extended and modified for practical police investigation by Sir E.R. Henry, the IG of the Bengal police in 1900. Some of Henry's methods have been used uncritically by scientists and until recently this had stood in the way of understanding the genetics and anatomical homologies of the patterns.

In the early part of this century, Harris Hawthorne Wilder initiated the study of dermatoglyphs in America. The Americans extended the study to palms and soles and compared them in twins and major races (ethnic divisions) of man as well as other mammals. The most extensive population survey throughout the world has since been conducted by the late Prof. Harold Cummins and his colleagues of the Tulane University, USA. He was the first to link dermatoglyphic peculiarities to congenital defects like extra fingers or toes and Down's syndrome (which is also known as mongolism or mongolian imbecility).

In Europe, Elizabeth Elderton, Kristina Bonnevie, Georg Geipe and Margaret Weninger attempted to discover a single pair of dominant-recessive genes for fingerprint patterns during this period. This resulted in refinement of quantitative methods

The sole of the Buddha in a second century carving (Indian Museum, Calcutta) represents the figurative similies of dermatoglyphic patterns The *chakra* (wheel) is equivalent to the whorl, the *sankha* (conch shell) stands for the loop and *padma* (lotus) for the arch



The configurations on the palm and sole

which paved the way for more successful studies in dermatoglyphic genetics. Bonnevie extended the method of ridge-counting to whorls and found out a relationship between pattern-size and thickness of skin. New insights also emerged from studies on Indian populations initiated by P.C. Biswas, S.S. Sarkar and their students. David C. Rife attempted genetic interpretation of ethnic differences and studied hybrid families. We have found indications that ridge-patterns may be related to colour blindness and skin colour.

Over the last three decades dermatoglyphics has been developed and used in the systematic application of biometric techniques and large-scale studies in chromosomal anomalies by L.S. Penrose and Sarah B. Holt at the Galton Laboratory, London. Holt obtained the first ever evidence of a nearly complete determination of a quantitative character by only a few genes practically without dominance (that is without one gene suppressing the effect of another on the same locus). She also found ideal values of correlation between finger ridge-counts of relatives. This work has been extended to finger, palm, sole and toeprints of a series of Indian families, and has led to the development of about 50 dermatoglyphic characters and a more comprehensive knowledge of their genetic basis. It also helped to propose simple and anatomically comparable methods of scoring pattern intensities, by using topological principles and formulae introduced by Penrose. The importance of triradii—the meeting point of three sets of parallel ridges—as basic dermatoglyphic landmarks developed out of these studies (see box on p.18).

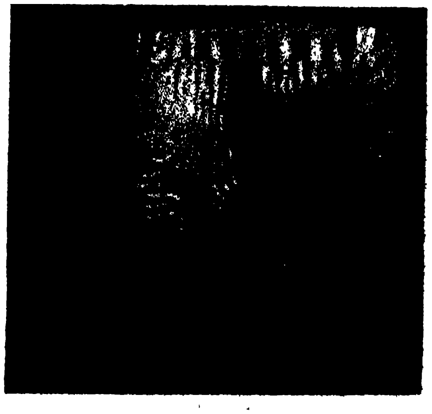
Recent work in Poland and India has led to further knowledge of the mode of inheritance of dermatoglyphic characters and to the modification of methods useful for clinical dermatoglyphics. We have obtained clear evidence of ethnic variability of palmar patterns by using suitable statistical methods, hitherto recognised only for finger patterns. In a study in Andhra Pradesh, it was found that the children of first cousins show an excess of both whorls and arches on fingers, and of patterns on certain areas of the palm. This strengthens the suggestions that a few additive genes are responsible for fingerprint patterns and that a few dominant-recessive genes for palmprint patterns. More intensive work in this line is being carried out at the Anthropological Survey of India.

How ridges form

How do ridge patterns form? The skin ridges run in parallel lines which curve gently. They turn round elevated muscular pads called volar pads, to form patterns, which reflect the shape and size of these pads in the fetus during eighth to tenth week. These bulbous pads usually subside by the third to fourth month of the intrauterine life. As a result, the skin begins to fold, first on the apexes of fingers and toes. By about the eighteenth week of the fetal life, these folds become ridges which then become sharp as the epidermis (the outermost skin layer) thickens due to cell proliferation. It has been recently observed in tissue cultures of epidermal cells taken from newborn infants that when oppositely moving cells of the deeper layer meet and press against each other, they begin to move upwards and form ridges. Short ridges fuse to form long ones and these turn into arches when local pressures are equal from both sides and into loops when these pressures are unequal (SCIENCE TODAY, August 1978, p.18).

Thick skin bears thicker and fewer ridges which generally result in arches and small loops, whereas thin skin folds more often into a larger number of ridges which form whorls and large loops. The more the skin is stretched by tension during waterlogging of the pads, the more will be the number of folds on it when the pad subsequently subsides. This can be verified by a simple experiment. If we expand a cel-

Ridges form when stretched skin of the volar pads is let loose Above, a heat expanded cellophane sheet is allowed to relax. The wrinkles are similar to dermatoglyphs



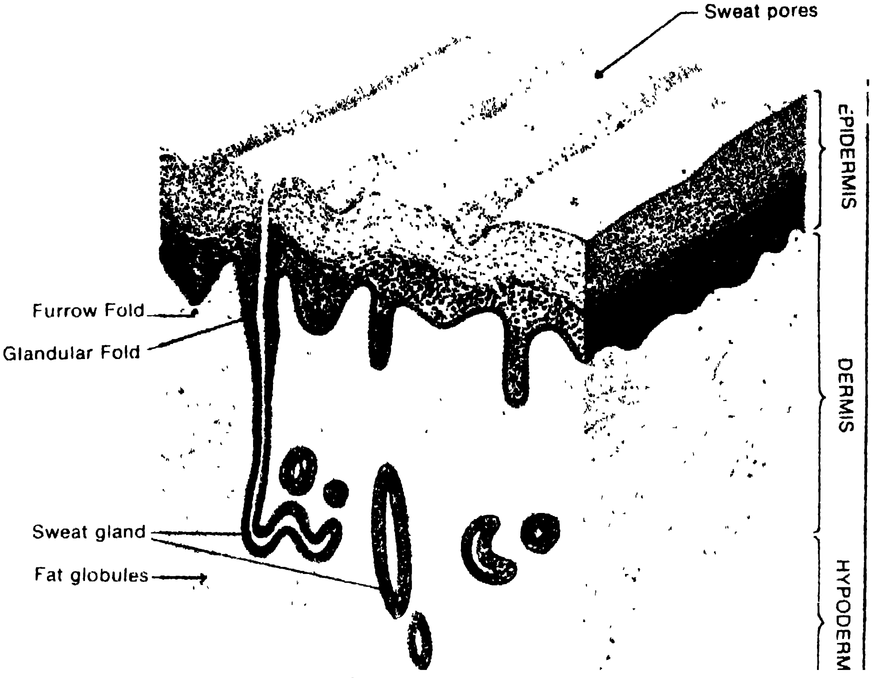
lophane paper by heat and stretch it with the help of three pins on a cardboard and then let it cool, patterns similar to dermatoglyphs form by ridges developing on the paper. Ridges are thus brought about by tension along the direction of ridges and compression at right angles to it.

Penrose had postulated that there would be more water inside cells containing many chromosomes than in cells containing fewer chromosomes. This means that water accumulation in the intercellular space in the latter condition would increase the number of folds on the skin during dehydration. Further evidence of this mechanism comes from dermatoglyphic studies in relation to chromosome numbers. Normal males have one X-chromosome and one Y-chromosome which is one-third the size of the X-chromosome; they have larger patterns on fingers than normal females with two X-chromosomes. Fingertips of individuals with fewer chromosomes than normal as for example in Turner's syndrome which is characterised by only one X-chromosome and no Y, bear large loops and whorls. Small patterns such as arches and small loops are common on fingers of individuals with more chromosomes than normal, such as in Klinefelter's syndrome, characterised by more than one X-chromosome and at least one Y. Rather small L-shaped loops also occur on fingers of individuals with an extra number of the chromosome-21, which causes Down's syndrome.

Indicators of chromosomal aberration

Dermatoglyphics thus provides a remarkable diagnostic criteria for chromosome aberrations. In some cases, these criteria are even more reliable than actual observation on chromosomes themselves because of the well-known errors of tissue culture. Pattern-size as measured by ridge-count (see box on p.18) can be useful when comparative data are available from the family or the population of the affected persons. But for efficient diagnosis, this has to be combined with other dermatoglyphic features. The epidermal ridges on a Down's syndrome affected palm, for example, are printed as dotted lines, which are called *leistenperlen* or "strings of pearls". The Down's individuals also have large patterns on the hypothenar area of the palm which is below the base of the little finger and near the wrist. These are more often ulnar loops which open towards the ulna bone of the forearm—that is on the side of little finger. The pattern results in a distal displacement of the triradius *t* towards the fingers, increasing the maximal *atd* angle to 80° on an average (in the palms of normal individuals, the *atd* angle is 45°, and barely are there any patterns on the thenar area or on the hallucal area).

Radial loops and small patterns on fingers, large patterns on thenar and hallucal areas of palms and soles, respectively, and large hypothenar ulnar loops characterise trisomy 13-15, also known as Patau's syndrome. (Trisomy is a condition in which three instead of two, as is normal, of a specific chromosome occur in the cells.) Arches on all fingers and very small incidence of patterns on palms and soles indicate trisomy—17 or 18. This condition, called Edward's syndrome is characterised by low-set ears, long head and small chin. Edward's syndrome babies are not likely to survive long. The Turner's syndrome also displays frequent patterns on the thenar area, a mean maximal *atd* angle of 65° and a large number of ridges between triradii *a* and *b* on the palm. Deletion of chromosome number 4 or 5 (which causes cat cry or *cri due chat* syndrome) also shows similar features as observed in Turner's syndrome—including increased pattern-size on fingers and large maximal *atd* angle on palms. Usually aberrations of larger chromosomes have greater amounts of dermatoglyphic changes,



Structure and function

THE outermost layer of the skin called the epidermis consists of four sublayers. The epidermal cells originate in the deepest layer, called the stratum germinativum, and rise up through the stratum granulosum (granular) and stratum lucidum (clear) to the top layer, stratum corneum where they become horny due to the lack of nourishment. The horny layer which constitutes about two-thirds of the epidermis is smooth and supple in the protected areas of the skin. But it is tough and ridged on the palms and soles for effective grasping. The epidermal ridges slant towards the same direction. This is an additional protection against slipping. On the sole, the alignment of ridges across the direction of motion helps walking.

Unlike the sweat on other portions of the body, the sweat on the palms and soles lack fat. The watery sweat discharged through the pores on the ridges further enhances the grasping ability of the hand. The sodium chloride in the sweat helps in detecting invisible fingerprints.

The ridges also enhance tactile acuity since there is a large supply of nerve endings and touch corpuscles through the double row of papillae under each ridge on the surface of the dermis. The capillaries contained in these papillae supply blood and nourishment to the germinating cells. It has been shown that the tactile acuity is greater when the stimulation is across the ridges than when along them The formation of patterns in which the ridges curve around in different directions prevents slipping and heightens tactile acuity irrespective of the direction of the stimulus.

Furrow fold and glandular folds project downwards from the stratum germinativum to fill the space between the upward projections of the stratum papillae of the dermis.

D.P.M.

but further work is needed to discover the exact extent of these differences in different populations with different genetic backgrounds But some of these deviations in individual dermatoglyphic traits like large maximal *atd* angles or large or small pattern-size on fingers may occur in apparently normal individuals or in unaffected relatives of persons with one or other of the syndromes

Mosaics are people who have two different types of cells in their body. Mosaic Downs are found to show a range of variation in dermatoglyphic features intermediate between the normal and mongol. But mosaic Turners are reported to differ very little from complete Turners. Most of these anomalies show a greater than usual degree of bilateral asymmetry but mosaics show still greater asymmetry. It is estimated from dermatoglyphic studies that 10 per cent of Down's mothers are mosaic Downs. Thus, dermatoglyphics could also provide simple tools for genetic screening of chromosomal anomalies and counselling about the risk of hav abnormal children.

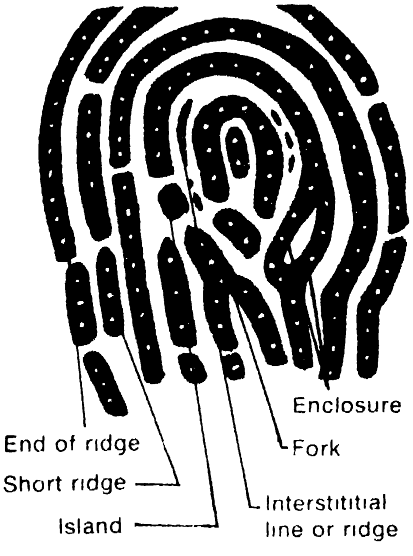
Much is otherwise known about the action of genes in determining biological variations in man, but these dermatoglyphic studies suggest how biological changes are also caused by multiplication or loss of entire chromosomes. Generally, the increase of size or number of chromosomes in man leads to reduction in pattern-size on fingers. There is a wide variation of status in either sex, but people show likenesses with near

What dermatoglyphists look for

THE dermatoglyphist generally concentrates on the ridges and the patterns formed by them The several parallel lines of ridges sweep smoothly across the surface They may bifurcate, turn around or just run up to the margins of the palm or sole. To study the configurations in detail an impression of the surface is made on glossy paper with printers' ink or by photographic methods. They are examined under a low power magnifying lens.

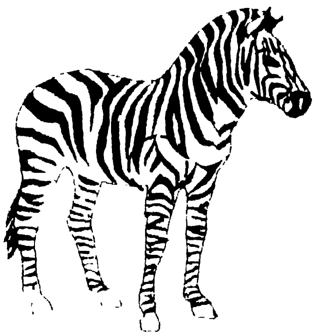
The fingers and toes are called digits and each segment of a digit is called phalange. The digits are assigned numbers one to five starting from the thumb or big toe The part of the palm or sole near the base of the digits is called the distal end. The part near the wrist or ankle is the proximal end

Microscopic view of the ridges



The landmarks of individual ridges are called minutae, which include (a) interstitial ridges which have no pores, (b) islands and short ridges with one or a few sweat pores,(c) forks and (d) enclosures or eyelets. The breadth of ridges and the number of sweat pores on them are also studied.

An important landmark is the triradius. A triradius is formed by three sets of parallel ridges which meet at angles in the range from 90° to 180°. When two ridges meet at an acute angle, it is called a fork. Sometimes three systems of parallel ridges meet to form a triangle with three acute angles. The triradius in such cases is located at the concurrence of perpendiculars on these ridge systems.

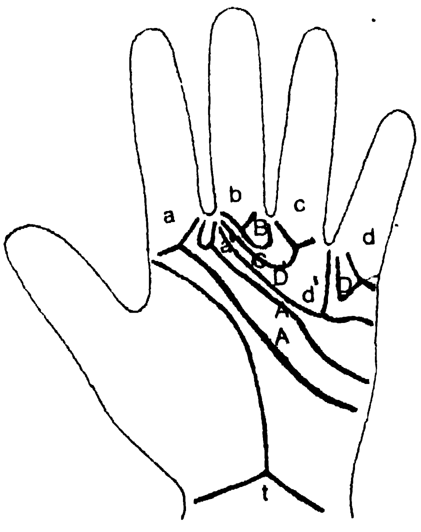


The triradii formed by the patterns on the Zebra skin A triradius occurs for each appendage beyond two

A triradius is an essential part of a visible loop, which is formed by ridges turning back through right angles. A whorl has two loops enclosed by four radiants of two triradii. Three interlocked loops with three triradii, which rarely occur on fingers but more often on toes, are considered as a complex sub-type of whorl. It is called an accidental pattern, but it is preferable to call it a superwhorl. An arch is a bell-shaped configuration of ridges often without a triradius; and a tented arch overtops a radiant of a triradius.

Parallel lines covering an area can form one or two loops without a triradius, but a triradius is topologically necessary for the formation of each additional loop. Similarly, parallel lines can run all over a figure with one or two appendages without any lines crossing at any point. But for each additional appendage the lines from three directions must meet at a triradius to make a carpet of parallel lines possible. For example, the parallel lines on the body of a zebra form a triradius at the base of each front leg and each side of the snout.

A normal palm or sole has four essential triradii because it has six appendages including the wrist (or ankle). The triradii at the base of digits 2 to 5, counted from the thumb or the great toe (digit 1), are denoted by *a*, *b*, *c* and *d* in order. Three of these, as also a triradius *t* on the proximal region of the palm (near the wrist) and the centrally placed triradius *p* on the sole, are essentially present without loops when there are five free digits. Often the triradius *c*, or alternatively *b* or *d* is either absent or accompanied by a loop

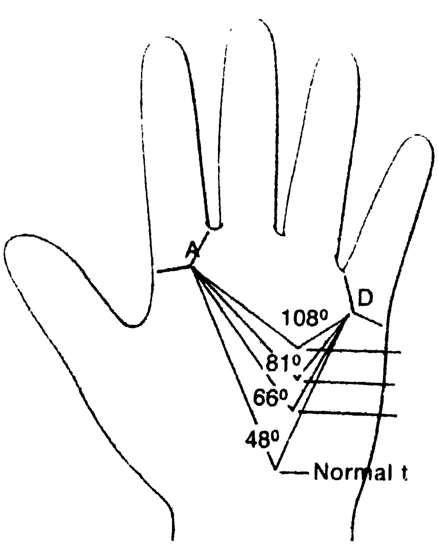


Two loops can be formed by parallel lines without the formation of a triradius but a third loop cannot exist without a triradius. For every additional loop there will be a triradius. There are four essential triradii—without a loop—on the palm. Triradii form the natural centres of main-lines and type lines. In the above palm there are three loops and therefore seven triradii

The number of triradii or the total number of loops on an area is a measure of the pattern intensity on that area. The pattern intensity is compared between areas, between hands and feet, between individuals and between groups of people. Triradii are also used for the study of other quantitative variations, the most important of which is the number of ridges crossed by a straight line drawn from a triradius to the point of core in a loop. The ridge-count is a measure of relatives. For example, normally XY males are taller than normal XX females on an average, and again they both are taller than XO females, the Turners. A similar situation is observed in dermatoglyphic variations. There are large degrees of overlapping in the variations in different types of chromosome constitution. Therefore, it is not possible to conclude without further family studies that genes for dermatoglyphic stereotypes of chromosomal aberrations are located on the concerned chromosomes.

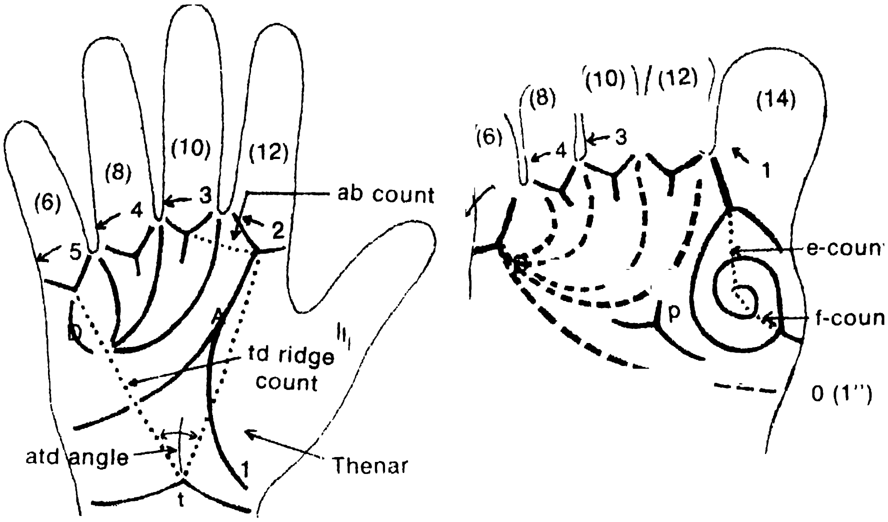
The epidermal ridges also provide records of irregularities in the process of growth during the third and fourth month of gestation. When a malformation occurs later than this, it is not reflected in dermatoglyphic features. If the fetal limbs are damaged as a result of genetic mutation or drug poisoning (as by thalidomide) the fact is reflected in the dermatoglyphs. In hereditary short fingers and toes (brachydactyly) the digits bear arches and small loops. This appears to be compensated by increased pattern intensity on palms and soles, large *ab* ridge count on palms and shift of the triradius *a* towards the margin. When the terminal phalanges of fingers and toes are absent in a hereditary anomaly called apical dystrophy, the extreme ends of digits show whorls or loops without any triradius. In another hereditary condition called anonychia, the nail is usually completely absent on some fingers and toes, and the ridges are found to extend over the area forming two

pattern size. The pattern size generally increases with the pattern intensity in the same individual or the same population. But the correlation between pattern intensity and ridge-count is not perfect, when different groups of people are considered together. For example, the average pattern intensity of the British population is lower but larger than the average pattern size of most of the Indian populations when fingerprint patterns are compared. Therefore, pattern intensities and pattern sizes are studied as different traits. The total ridge-count on fingers is obtained by summing up the larger counts (when there are two loops) of 10 digits to measure the overall pattern size. A new measure called absolute ridge-count is obtained by adding up the ridge-counts of both radial and ulnar loops over fingers or toes. The absolute ridge-count measures both the pattern size and pattern intensity at the same time. This measure gives a clearer trend of variation between ethnic populations than the total ridge-count.



Palm showing normal position of triradius *t* and the displacements in certain congenital disorders

In certain birth defects, the triradius *t* shifts towards the distal end of the palm, that is, towards bases of the fingers. The shift of *t* is measured by the maximal *atd* angle, which is formed by lines joining the most distal triradius *t*, when there are more than one, with the triradii *a* and *d*.



Landmarks on the palm and sole and the measures of D-line curvature The numbers in brackets assigned to D-line endings are a measure of horizontal alignment

But this angle is age-dependent and therefore, the *td* ridge count is more dependable in growing children

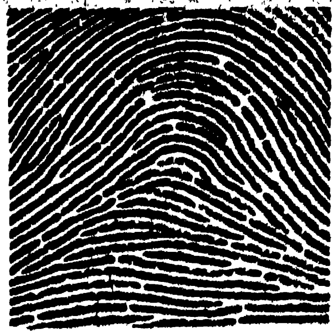
The longest of the three radiants of any of the triradii *a*, *b*, *c* and *d* is directed towards the centre of a palm or a sole and usually ends in a margin. This is called a mainline. The mainlines of the triradii *d*, *c*, *b* and *a* are called D, C, B and A. The mainline is assigned a numerical value such that the higher the number, the greater is the degree of horizontality. The inclinations of the mainlines are mutually dependent. Therefore, a mainline index is derived by adding the values assigned to mainlines D and A. The purpose of this is to depict the general direction of ridges which differ between right and left side, between individuals and between populations. In Down's syndrome, the mainlines are more horizontal in normal individuals. Caucasoids generally show a greater degree of palmar mainline horizontality than the Mongoloid or the African. In general, the right hands of individuals exhibit more horizontality than the left, and men's hands more than women's. Their palmar main lines exhibit greater horizontality than the hands of the African or Mongol.

Specific dermatoglyphic areas display specific configuration trends. Whorls and larger patterns occur most frequently on first and fourth fingers and on third toes in normal individuals. The loops are most frequent on the fifth finger and the fourth toe. The arches and radial loops are more common on the index and middle finger and are more frequent on toes than on fingers.

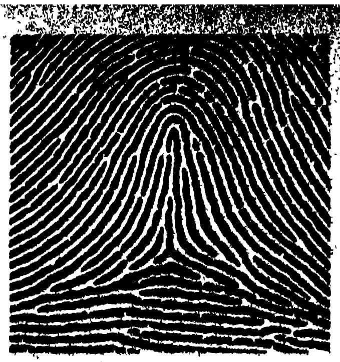
There are also definite trends of bilateral difference in each dermatoglyphic character and these differ in normal and malformed individuals. On an average, the right hands and feet have a larger pattern intensity on fingers and soles. A reverse bilateral trend is observed for toes and palms. The sex difference is slightly more marked than bilateral difference within individuals. The ridge-count on fingers is, on the average, greater in males than in females, but the pattern intensity and ridge count on palms appear to be larger in females than in males.

The imperfect ridges are also examined to locate developmental disturbances during ridge formation. A hereditary condition has been found in which the ridges do not form at all on palms or soles due to loss of epidermis before birth. The ridges are seriously disturbed by certain skin diseases such as leprosy or eczema

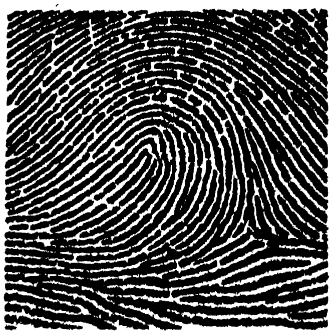
D.P.M.



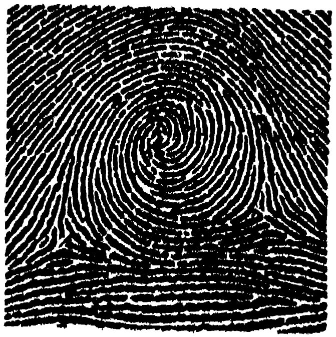
Simple arch



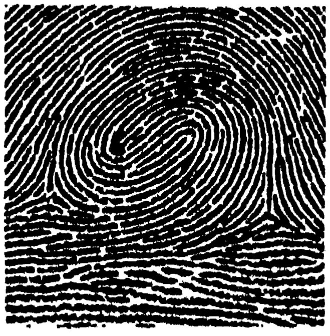
Tented arch



Loop



Whorl (spiral)



Whorl (double loop)

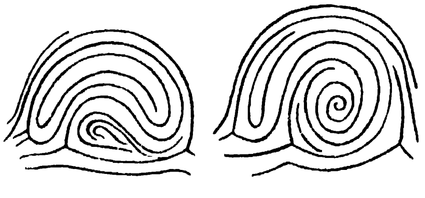
Some common dermatoglyphic patterns. One triradius is necessary to form a loop, and for a whorl, there are two triradii. The ridge count is taken as the number of ridges between the centre of the pattern and its accompanying triradius. (For whorls, naturally there are two counts.) The ridge count is also used in diagnosing certain conditions

loops without accompanying triradii normally covered by nail. From these observations, it is obvious that triradii are essential in a system of parallel ridges when there are more than two loops or two appendages. It follows that on a palm with six appendages—that is five fingers and the wrist—there are four essential triradii with loops. Each loop on the palmar surface of fingers is essentially accompanied by a triradius, because the nail is to be considered as a substitute of two loops without triradii. (A whorl is a combination of two loops and has therefore two triradii on usual fingerprints.) Each additional triradius indicates the presence of a loop or an extra finger in early fetal life before ridge formation. Developmental absence of digits (ectrodactyly) has the reverse effect on the number of triradii on the palm or the sole.

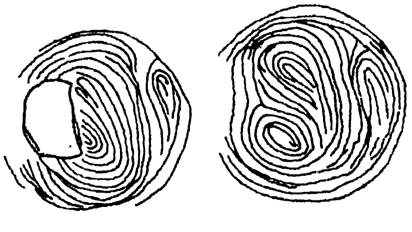
There are a large number of clinical reports about dermatoglyphic patterns in milder congenital defects, hereditary diseases and disorders. But evidences are often contradictory and sometimes flimsy. These controversial results are concerned with large maximal *atd* angles in congenital heart disease, schizophrenia, diabetes mellitus, leukemia, leucoderma, leprosy, rheumatic fever, bronchial asthma and others. The dermatoglyphic differences of such conditions, when they occur, are far from diagnostic in value. However, it is quite possible that even small differences displayed by some disorders may help to indicate the genetical basis of the concerned diseases or their susceptibilities.

Some of the clinical studies in dermatoglyphics suffer from lack of suitable methods or designs. Dermatoglyphs, like other hereditary variations, differ in the different populations. Patients often come from heterogeneous genetic and environmental backgrounds, and it is difficult to obtain suitable control data for comparison. Unaffected siblings or parents may carry part of the genetic background of the disease; hence, studying the patients' same-sexed relatives in such cases is useful. Also, it is necessary to accumulate dermatoglyphic data from specific populations. With such careful designs of study, it has been possible to find systematically that the patients of a severe kind of hereditary anemia called thalassemia have larger ridge-count and pattern intensity on fingers than has the normal Bengali speaking population of Calcutta. But patients with genes for thalassemia and another abnormal hemoglobin, called hb E, show rather small intensity of fingerprint patterns. There are also increased numbers of hypothenar and second interdigital patterns on palms of thalassemia patients. In this severe defect of hemoglobin synthesis, there is a compensatory mechanism of rapid formation of blood cells, and this may enlarge bone marrow and influence the bones of the limbs. Dermatoglyphic variations in this case are not of as much diagnostic value as in skeletal deformities, but results from other countries do suggest that dermatoglyphics could be used in future also for the genetic screening of this widely occurring hereditary anemia, which may be followed up by other newer techniques of diagnosis.

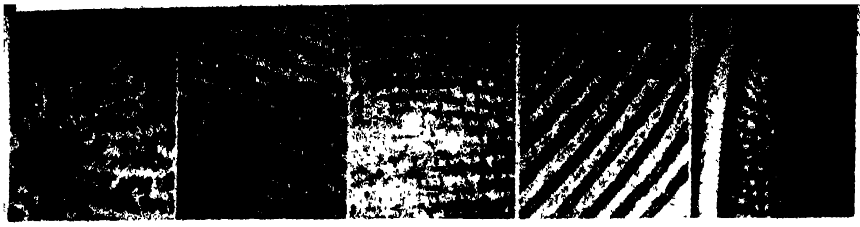
Anthropological surveys reveal more consistent ethnic trends of variation in dermatoglyphics than other hereditary traits including physical measurements. The incidence of whorl patterns on fingers, for example, is about 40 per cent in many Indian populations and in peoples of west Asia. The frequency rises to above 70 per cent in the Eskimos and in Australian tribes, 60 per cent in some tribal populations of central and southern India, and above 50 per cent in the Naga and Bodo group of populations in north-eastern India. The



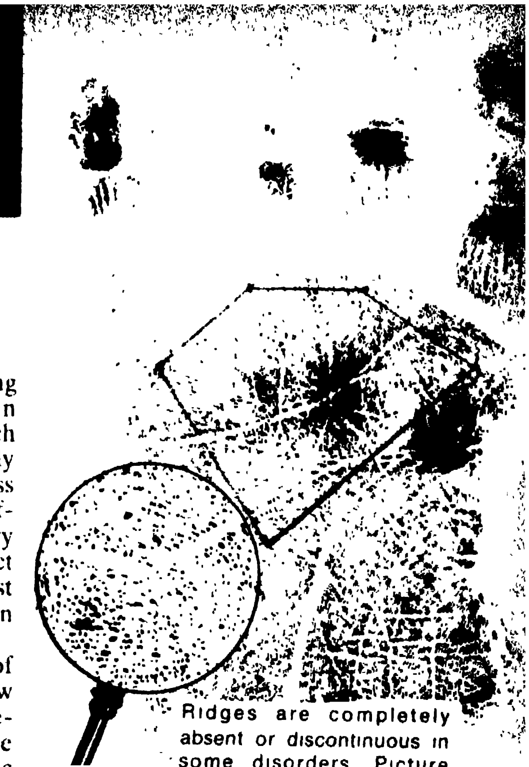
A superwhorl, also known as accidental whorl, occurs normally on toes—especially on the third toe—rarely on fingers



In the congenital absence of nails, dermatoglyph patterns form in the area which ought to have been covered by the nail



The formation of ridges and papillae in the human fetus and other primates From left surface of macaque palm, surface of thenar area of tupaia sole, hypothenar area of the palm of the slow lorris, palm of the human fetus (20 weeks of gestation) and walking pad of a rat's hind foot



Ridges are completely absent or discontinuous in some disorders Picture shows the palmprint of a Down's syndrome baby. Note bead-like ridges

values of finger ridge-count are however larger in west Europeans than Indians. In the Zaire (Congo) region of Africa, the Bushmen show the largest proportion of arches in the world. In the Kuki-chin speaking and other populations of north-eastern India there is a very low intensity of palmar patterns as compared to the rest of the Indian population, Europeans and Africans. The most horizontal alignments of palmar mainlines (see box on p.18) are very frequent in the Caucasoid people, and rarely occur in Africans and some tribal populations of India. The male samples from widely varying genetic populations, such as Japanese, Chinese, German, Bengali, and a number of populations of north-east India show a small range of variation—18 to 25 per cent whorls and 19 to 22 per cent arches on toes. The underlying cause of ethnic differences are genetic to a large extent. Differential timing of fetal growth has also been suggested as a mechanism of such genetic diversification. It is usually believed that dermatoglyphs are less adaptive to environmental differences. However, the preliminary data for differential fertility in respect of dermatoglyphic features suggest the operation of natural selection on these characters as well.

An age-old and obscure field of microanatomy has thus assumed new importance for study of human genetics and medical anthropology. The use of dermatoglyphics for genetic surveillance, it is hoped, will become immensely important for future programmes of public health. The association of dermatoglyphs with other physical characters and single gene traits such as Lewis blood group has not yet been fully explored. There are some indications that dermatoglyphs change through generations, which opens up new fields of study in population genetics. Dermatoglyphics again has developed as a field for application of mathematical principles to biology which is not limited to biometrical genetics but also to geometry and topology. The identification of the essential elements of patterns seem to have wide implications for art and industry. The science of dermatoglyphics has reached a threshold and further rapid advancement is likely to take place through collaborative research involving many disciplines and feedback of the results into each of them.

Personal Identification

JUST as the dermatoglyphic similarity between individuals forms the basis of population comparison, the dissimilarity in the ridge details between any two individuals makes it possible to use fingerprints for criminal investigation.

The knowledge of uniqueness and permanence of dermatoglyphic variations led to their use as marks of identification in gate-passes, contracts and representations of ancestors both in India and China. There are Chinese records about the use of fingerprints in an ancient kingdom of southern India. The evidence about their use in ancient China comes from a clay seal of the third century BC a contract of loan of the eighth century and a sale deed of the 16th century.

By 1900 Sir E.R. Henry, Inspector General of Police in Bengal, along with Khan Bahadur Azizul Haque and Rai Bahadur Hemchandra Bose, developed a method of sorting out fingerprints of criminals into 1024 pigeon holes and devised a mathematical formula for locating individual prints. An official fingerprint bureau was opened under the Calcutta Police in July 1897. Identification of criminals on the basis of fingerprints alone, thus, commenced in India. Its success attracted other countries.

Dermatoglyphs are immutable except that they enlarge with age. They persist until the epidermis decomposes or its deepest layer is seriously damaged. Ridge patterns on the fingers have been discovered on an Egyptian mummy's palm at the British Museum, preserved for over 2,000 years. These patterns can be permanently printed and are latently impressed on any surface they touch.

Fingerprints can be classified and sub-classified indefinitely as required. The chances of two patterns—ridge-counts in two different loops, and the general appearance of ridges—being identical on two prints is estimated by the product of their population frequencies, and it is obviously extremely small. When these minutae are also compared point for point between the evidence print' or 'chance print' with the 'identifying print' kept in the record files, the chances of agreement are so low that it is practically impossible to find a duplicate fingerprint. So far, even after millions of prints have been analysed throughout the world, no two fingerprints have ever been found to be identical, not even in twins who have the same genetic constitution.

D.P.M.

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New methods in dermatoglyphics

B. Vijaya Bhanu

THE Galton system of fingerprint classification proposed three basic fingerprint pattern types (arch, loop and whorl) whereas the Henry system succeeded in further sub-classifying each of the basic patterns and recognised thirteen pattern types in all. Both the systems have their own merits and limitations. A few of them are listed below.

Depending on the nature of inquiry, the researcher has to choose any appropriate classification. The Galton system being a gross classification has only limited use in scientific investigations while the Henry system is very popular with fingerprint experts, and is still being used by physical anthropologists for studying population variations.

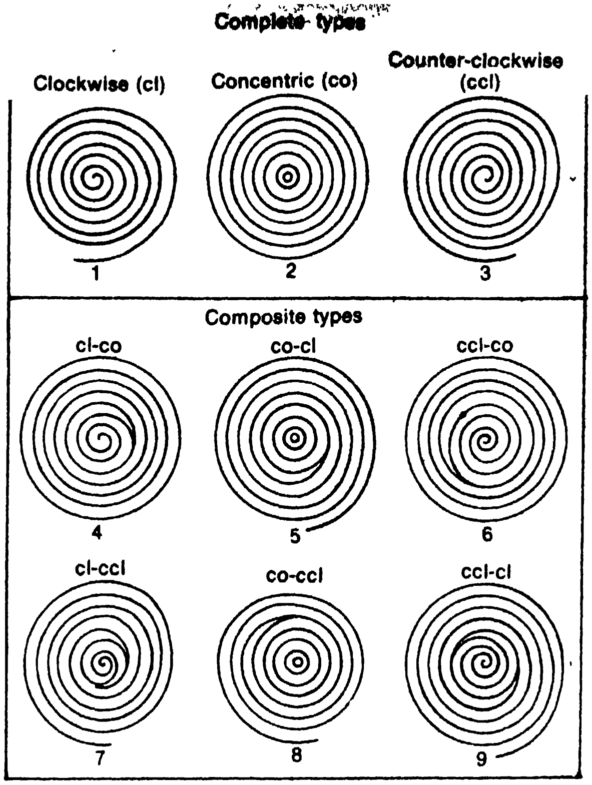
With recent advances in medical genetics and population studies, in India and elsewhere, dermatoglyphics is also being widely used in these fields. Thus, some of the existing methodologies of study and more so the classification of fingerprint patterns need modifications. The existing classifications, being arbitrary, are not suitable for studies relating to inheritance, and diseases, where the minute details of the ridges *vis-a-vis* the patterns are essential.

Though the Henry system identifies a few of those pattern variations in whorl patterns, it failed to adopt the anatomical basis for the pattern especially in the case of true-whorls where the sub-classification is completely arbitrary and illogical. All the classifications given under are based on anatomical orientation of the patterns.

This would facilitate easy comparison between pattern types—arch, loop and whorl—which is not possible with the existing classifications.

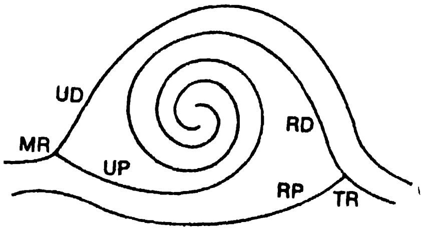
A few studies undertaken with the help of these classifications have yielded encouraging results in comparing populations as well as in investigations relating to diseases. An evaluation of their usefulness in the fields of heredity and personal identification are in progress.

Of the three basic patterns—arch, loop and whorl—the whorls are the most complicated patterns with varying morphological features inside the pattern area, which is formed and circumscribed by the pattern radiants. These pattern radiants emanating from each triradius present varying courses. From each triradius one pattern radiant in whorls and loops courses to the marginal area of the digit while the remaining two pattern radiants (distal and proximal) independently or in combination with their corresponding radiants of the other triradius render different morphological contours for the whorls. The courses of these pattern radiants could be identified and classified, depending on the specific radiant contributing to the pattern formation, or its relation with the other radiants



There are three basic types of whorls. The six sub-types are characterised by a pattern area with two types of ridge courses combined together. The combinations as they appear from 'inside out' are: clockwise-concentric (cl-co), concentric-clockwise (co-cl), counter-clockwise- concentric (ccl-co), clockwise-counter- clockwise (cl-ccl), concentric-counter- clockwise (co-ccl), counter-clockwise- clockwise (ccl-cl) Patterns with more than two types of ridge courses are not included in the present scheme of classification, since they occur rarely. However, they could as well be identified and classified following the above method

Like the loops, the whorls, though formed by the coiling of ridges from the core, try to open at one or both the margins of the digit. If the spiral formation of the ridges takes more than one circuit, it would generally open below a triradius. By tracing the core and the pattern radiants, the pattern opening could be identified and classified with its relative position with the triradius and the margin where it opens.

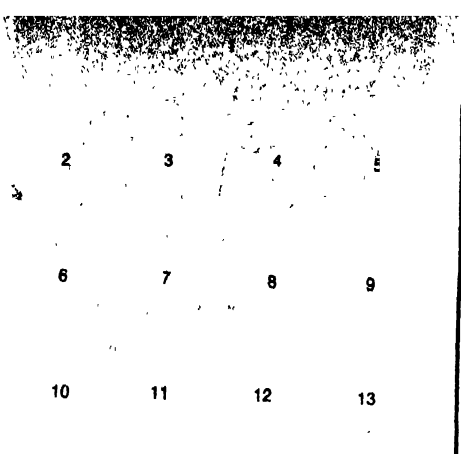


Pattern radiants of a whorl (diagramatic) from the digit of the left hand UD: Ulnar distal. UP: Ulhar proximal. RD: Radial distal. RP· Radial proximal. TR: Triradius MR: Marginal radiant

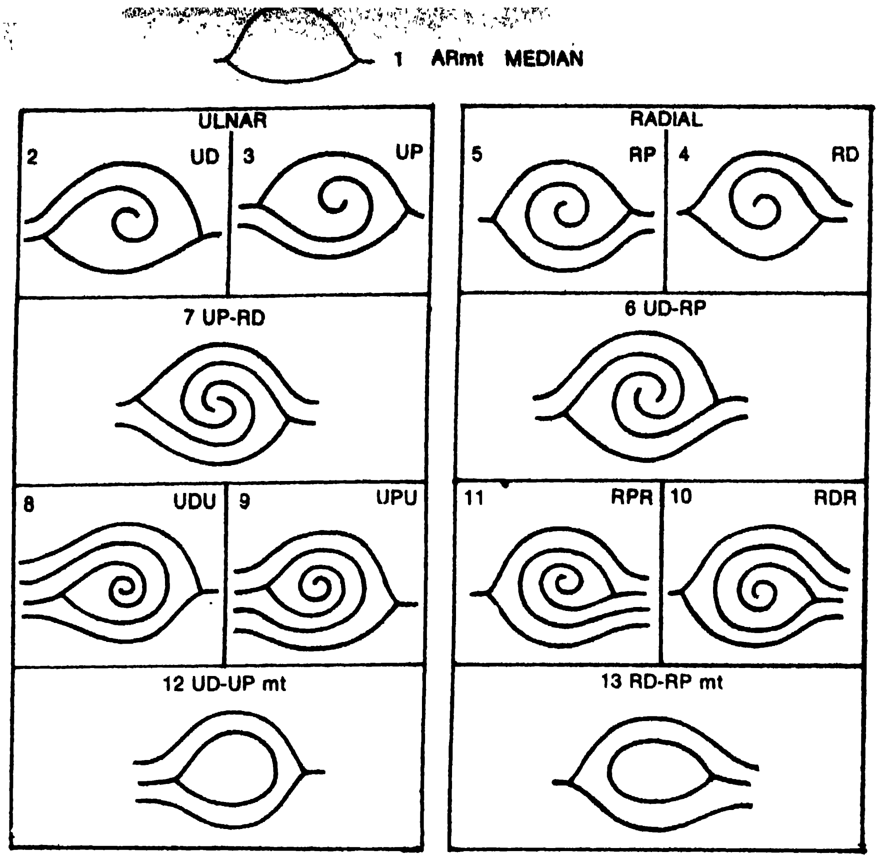
The ridges inside the pattern area in whorls are generally arranged in concentric or in spiral formation. When the core is traced out, the nature of the course of these ridges could be identified and classified under three basic types.

Type 1: clockwise (cl). The ridge system inside the pattern area takes a spiral course. The direction of the ridges when traced from inside will be

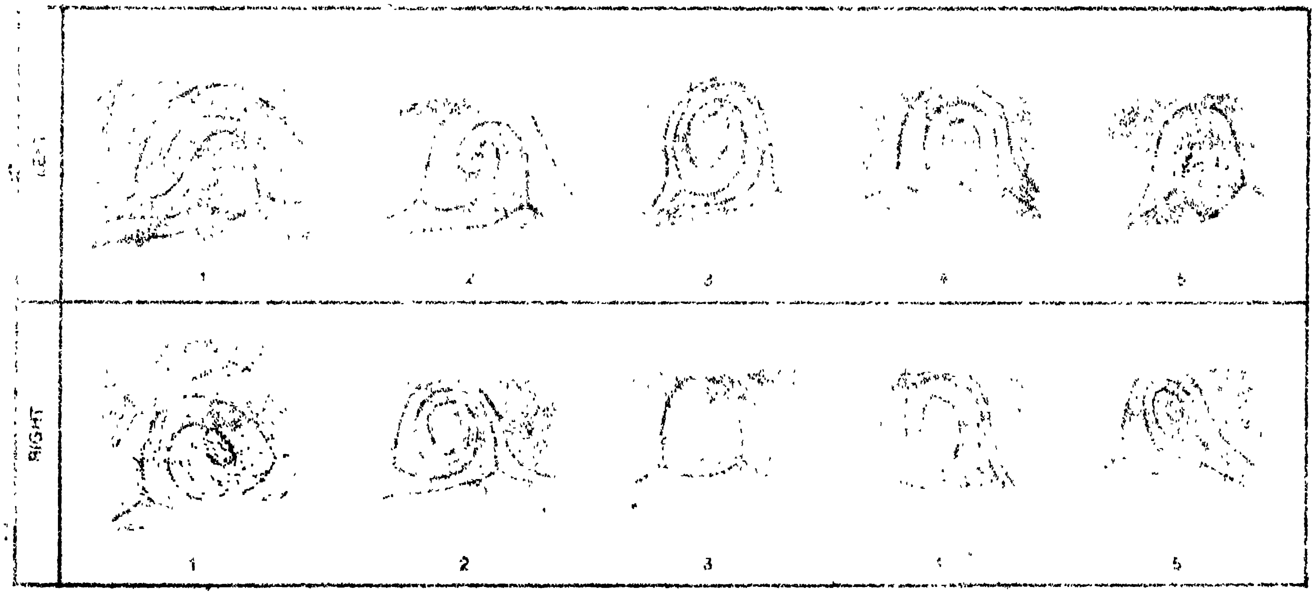
	Merits	Limitations	Merits	Limitations
1:	Very popular and easy to follow.	No anatomical basis followed. Gross classification.	Popular and very affective in personal identification.	Anatomical basis is not followed throughout. Sub-typing of true-whorls is arbitrary.
2.	Includes all patterns.	No detail features considered.	More categories and sub-types available.	Comparison between patterns is not possible.
3.	Broad generalisation of the data possible.	Not useful in studies of inheritance or in disease investigations.	Could be converted into Galton types.	All the pattern variations are not included.



Classification of the simian crease types 1. Transitional 2. The distal crease 3. The proximal crease 4. The parallel crease 5. Complementary bicrease 6. Complementary proximal crease 7. Complementary distal crease 8. Complementary-vestigial (proximal) 9. Complementary-vestigial (distal) 10. Vestigial bicrease 11. Vestigial proximal crease 12. Vestigial distal crease 13. Typical simian (transverse) crease (after Bhanu, 1972)



Course of pattern radiants and pattern opening. U stands for ulnar, R for radial, P for proximal, D for distal, mt for meet and AR mt for all-radiant meet type ▶



igerprints
assified
ording to three

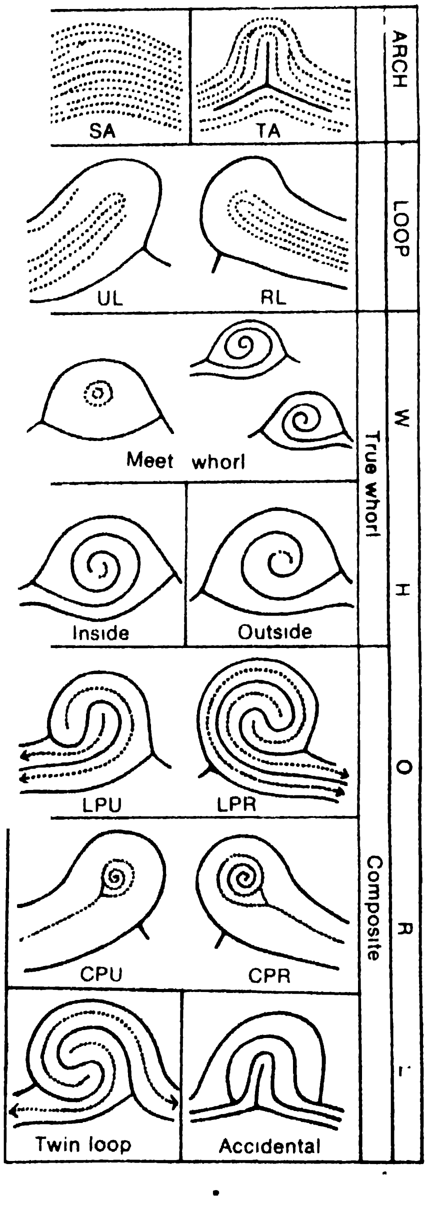
Hand	LEFT					RIGHT				
Digit	1	2	3	4	5	1	2	3	4	5
Galton	W	W	W	W	L	W	W	W	W	W
Henry	TL	IW	IW	MW	UL	OW	IW	MW	MW	CPU
Bhanu (Course of pattern radiants)	UP-RD mt	UP-RD	UPU	RD	UL	UP	UD-RP	AR mt	UDU	UPU
Ridge course	cl	cl	cl	cl		ccl	cl	ccl-co	cl	ccl
Pattern-opening	UP-RD	UP-RD	UP-UD	RD	U	UP	RP-UD	O	UD-UP	UP-UD
Pattern Type	UW	UW	UW	RW	UL	UW	RW	MW	RW	UW

clockwise. One or more cores may be present. Type 2: concentric (co). The pattern area is composed of ridges circumscribing one after another in a circular or elliptical fashion. A core point may or may not be present. Type 3: counter-clockwise (ccl). The spiral course of the ridges takes a counter-clockwise direction, the mirror image of type 1. Single or multiple cores may be present.

It has been observed (on prints) that more than 90 per cent of the whorls from the digits of the right palm have ridge courses which are counter-clockwise (ccl) in direction while the whorls on the digits of the left hand show clockwise(cl) ridge courses when the core is traced from inside out.

Classification of the finger patterns according to Henry system (13 types) contrasted against Galton system (3 types) Left hand digits considered for the drawings

SA: Simple arch. LPU Lateral pocket ulnar. TA· Tented arch LPR Lateral pocket radial. UL Ulnar loop. CPU· Central pocket ulnar RL Radial loop. CPR Central pocket radial



On the palm, the mainline formulae with their bilateral, bisexual and population differences have been widely used in physical anthropological investigations. Of all the mainlines, the C-line is found to be highly polymorphic in its courses, and is characterised often by its abortive nature and absence. It has shown good results when populations are compared. In disease investigations also, mainline C is found to be quite useful.

Although initially the dermatoglyphic studies did not recognise the creases on the palm for studies Cummins and Midlo realised their importance. The three main creases are formed in early fetal life and do not change their characteristics or courses afterwards.

Of the three main creases (distal, proximal and radial longitudinal), the first two creases show deviations in their courses and at times are fused to form a single crease (simian crease) across the palm. Such creases are more often found on the palms of the apes and hence the name. Recent studies have indicated that such transverse creases are significantly frequent among people with chromosomal anomalies. About 95 per cent of the palms of patients with Down's syndrome are characterised by simian creases. In the general population, too, the incidence of different types of simian crease is met with up to 10 per cent.

The plantar (sole) area remains to be the least investigated part in dermatoglyphics, mainly due to difficulties in obtaining good prints. It is nearly impossible to get rolled impressions of the toes and also to get impressions of the arched part of the sole. However, the general features and landmarks remain same as that for palmar prints.

There are a number of easily observable features formed by the ridges and creases on digits, palms and soles which have not been adequately investigated. Their variations on finger and palmar areas, if properly investigated, would yield fruitful results for physical anthropologists to study human variations, for fingerprint experts in personal identification and for doctors as an aid to diagnosis.

Dr. Bhanu is reader in Physical Anthropology, University of Poona. He has published more than 30 research papers on various topics in anthropology.

New revolution in coded communication

Now computer scientists have employed ingenious methods to design practically unbreakable codes — also an introduction to the tricky art of making and breaking secret messages.

Disasters: facing the '80s

Natural disasters will claim more lives in future since there will be more people around. What are the new methods that can help reduce the toll?

How not to carry out an experiment

During the recent solar eclipse quite a few unscientific experiments were carried out. How does a true scientist plan investigations?

Olfactory invitation cards

Insects can almost smell their mates from miles away. Scientists are trying to mimic the females' luring charm — odoriferous chemicals — to monitor insect populations.

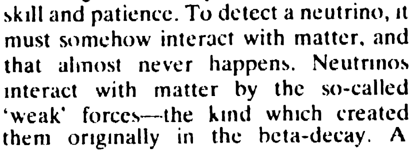
The case of the "missing neutrinos

NEUTRINOS are once again in the news. They seem to be changing their identity during their travel. Experiments by F. Reines, H.W. Sobel and E. Pasierb of the University of California at Irvine, seem to imply that nearly half of the neutrino population at a nuclear reactor changes its identity by the time it travels a few metres from the reactor core.

Nuclear reactors are excellent sources of neutrinos because many of the radioactive nuclei created during fission eventually beta-decay, releasing an electron and an attendant neutrino. Physicists call this neutrino from the reactor, for the purposes of book-keeping, the 'anti-neutrino of the electron-type'. So far—although three types of neutrinos have been discovered (e-type, mu-type and tau-type, which has yet to be confirmed) in the experiments with accelerators—there has been no evidence that a neutrino of one type changes into another type. The results of the reactor experiment to be published shortly in *Physical Review Letters* suggest a mixing among the neutrino types.

Neutrinos are notoriously elusive and detecting them requires extraordinary skill and patience. To detect a neutrino, it must somehow interact with matter, and that almost never happens. Neutrinos interact with matter by the so-called 'weak' forces—the kind which created them originally in the beta-decay. A momentous discovery of the past decade was that neutrinos interact with matter by another variety of weak force called the 'neutral' variety, so named because under its influence the electric charge of the participants does not change. In the forces that control the beta-decay, however, the electric charge jumps from one participant to the other. This kind of force was later named the 'charged' variety of weak force.

Reines and co-workers exploited this ambi-dextrous property of the neutrino. Their experiment consisted of figuring out the break-up of a deuteron in the heavy water by both varieties of weak forces. The 'neutral' variety causes a single neutron to come out, while the 'charged' variety causes the release of two neutrons along with a positron. So they undertook to 'count' the neutrons by counters immersed in a 268-kg pool of heavy water exposed to neutrinos from the 2,000 megawatt Savannah River Reactor located at a distance of 11.2 metres. They found that the ratio of the number of deuteron break-ups by the weak forces of the 'charged' variety to those by the 'neutral' variety, was about half of what was expected.



Neutrinos appear to oscillate continuously. Reines compares this to the effect of seeing a cat changing into a dog and back again into a cat and so on,

This result is understandable in a simple way if we suppose that during the 11-metre travel to the apparatus, about half of the reactor neutrinos got changed to neutrinos of another type which cannot break up the deuteron by the charged weak forces, whereas the break-up of deuteron by the neutral weak force is 'indifferent' to the type of neutrino. These changes among the neutrino types, called neutrino oscillations, can occur back and forth many times over.

The extremely fascinating concept of neutrino oscillations was conceived originally by the Japanese team, Z. Maki, M. Nakagawa and S. Sakata in 1962, and by B. Pontecorvo in Russia in 1968. According to quantum mechanics, a wave can be associated with a particle of definite mass. One may imagine the e-type neutrino to be a combination of only two such matter waves, each referring to a different mass. As the two waves travel together, they get in- and out-of-phase with each other, and the interference among the waves then leads to oscillations in the numbers of the e-type neutrinos.

The recent experiment implies that at least one of the masses of the two underlying waves (Reines called them 'neutrettos') must be more than about an electron-volt. That may not sound big compared to the electron mass of 511,003 electron-volts; but even the small mass is exciting since neutrinos are commonly believed to have no mass at all.

There are several interesting puzzles—big and small—which will start clearing up if there are neutrino oscillations. A very interesting one refers to the 'Kolar events'. In 1975, an Indo-Japanese team of physicists from the Tata Institute of Fundamental Research, Bombay, and the University of Osaka, working at the Kolar Gold mines in Karnataka reported some puzzling events produced by the atmospheric neutrinos. Other experimental groups using neutrinos from particle accelerators have not been able to confirm these observations.

If there are neutrino oscillations however, the Kolar events can be explained. K.V.L. Sarma and L. Wolfenstein pointed out in 1976 that some of the e-type neutrinos in the atmosphere oscillate into a different type which are responsible for the Kolar events. The accelerator neutrinos have fewer of the e-type; they do not travel 'long' enough for the oscillation. The famous solar neutrino puzzle (R. Davis detected fewer neutrinos reaching the earth from the sun than expected from theoretical calculations) becomes less serious if there are neutrino oscillations. In any case, a confirmation of this important discovery of Pasierb, Reines and Sobel, by other groups and under different conditions of the reactor running is eagerly awaited.

K.V.L. SARMA

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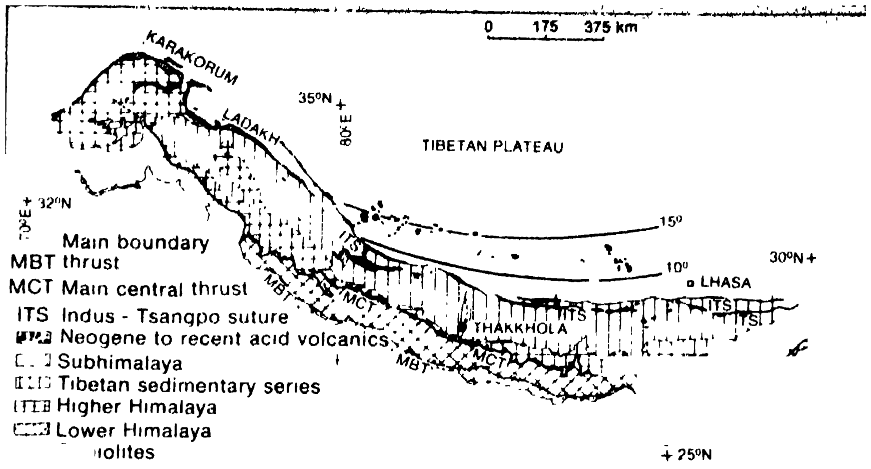
New facts about India-Asia collision

THE HIMALAYAS, the world's highest mountains, and the adjacent Tibetan plateau have always attracted the attention of geologists because the thickness of the earth's crust there is estimated to be double the average thickness. On the basis of the continental drift hypothesis, this large crustal upliftment was the result of the India-Asia collision.

Extensive geological and geophysical data obtained from continents and oceans during the last two decades have led to the ideas of ocean-floor spreading and plate-tectonics. According to the ocean-floor spreading theory, molten material rises from the earth's mantle from time to time through the fissure centred on a ridge and pushes the earlier solidified rock material, resulting in the spreading of the ocean-floor; at some other part of the earth, the ocean-floor plunges into a trench and sinks into the mantle. According to the plate-tectonic theory, the outer shell of the earth consists of a number of rigid plates. Seismological data suggest that an outer rigid zone, 70 to 150 km thick (the lithosphere), probably constitutes the rigid plates. The lithosphere is discontinuous at the plate-boundaries. These plates are in constant relative motion; they can simply slide past each other or they can converge, in which case plates must be consumed: that is, they may give rise to mountains or earthquakes, or they may sink in.

In the light of these ideas, the evolution of the course of the India-Asia collision appears to have taken place in two stages. In the first stage of collision, a suture zone was formed around 50 to 60 million years ago and India's drift slowed down. In the second stage, about 20 million years ago, a crustal fracture developed inside the Indian block itself and the continental material started subducting beneath the suture zone and Asian landmass.

Recently, D.K. Bingham and C.T. Klootwijk from the Australian National University, Canberra, (*Nature* **184** p.336) have estimated the underthrusting of the Indian continent with the use of paleomagnetic technique. When a rock



Main structural features of the Himalayas are shown in the figure The anticlockwise rotational movement of Greater India with respect to its former leading edge, Indus - Tsangpo Suture, is estimated by the present study to be about 10-15°

mass is formed, either by the cooling of the liquid magma or the consolidation of sediments, it gets magnetised in the direction of the geomagnetic field The magnetisation thus acquired becomes a permanent record of the direction of the geomagnetic field of the place where the rock is formed Bingham and Klootwijk have studied paleomagnetism of the Tibetan rocks which lie beyond the thrust zone. When they compared the paleomagnetic results of Tibetan and Indian rocks, an anticlockwise rotation of about 10° to 15° of the Indian subcontinent with respect to the Tibetan landmass was indicated. If it was assumed that this differential rotation was restricted to underthrusting along the main thrust zone, then a 10° to 15° rotation corresponds to a minimum underthrusting of 200 to 350 km of the Indian continent beneath the former leading edge and the Tibetan plateau

One has to keep in mind that there is a controversy about where exactly the Indian and Eurasian plates collided. From studies of the deep seismic data and distribution of earthquake epicentres in and around the Himalayas, Indian scientists, K L Kaila and Hari Narain, had earlier postulated that the two plates collided farther north, beyond the Tibetan block, instead of at the Indus-Tsangpo suture.

Although Bingham and Klootwijk's conclusion is interesting, it is based on several assumptions and needs to be verified with other techniques. The small angular difference of 10° to 15° in paleomagnetic directions is just comparable to the scatter in the paleomagnetic directions of individual formations. Hence such a conclusion, though not be acceptable to all, can stimulate further work on this problem.

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An unusual supernova remnant

STARS ARE mortal. A good number of the stars we see today will blow up at the end of their 'life' The blowing up of a star is called a supernova event (SNE) To a distant observer, such an event appears as the waxing of a star or even appearance of a new star An SNE could outshine Venus in the sky and may even be visible during daytime for 10 to 20 days. Then the brightness wanes and the star is lost into oblivion Chinese astronomers, a few thousand years ago, referred to these events as the appearance of 'guest stars'.

An SNE involves the release of enormous energy (about 10^{49} to 10^{51} ergs), most of which is transferred to the debris of the star (referred to as supernova remnant or SNR). This remnant expands radially in space sweeping the interstellar medium.

An SNR harbours high-energy electrons which radiate copiously at radiowavelength in an intense magnetic field. After formation, SNRs are believed to be observable in radiowavelengths for a period of about 100,000 years. More than a hundred SNRs are known in our galaxy. Radio astronomers have measured parameters such as their spectra and the polarisation properties of the radio emissions. In addition, they have studied the brightness distribution across these sources at high resolution. They use data to estimate an SNR's age and distance and to make educated guess about the physical condition in the SNR. Although, a minority of the remnants could be studied with optical telescopes, these have provided valuable information about the motion of different parts of an SNR. (Because optical radiation is characterised by spectral lines that get doppler shifted due to the motion of the emitting region.)

R. G. Strom of the Netherlands Foundation for Radio Astronomy, P. E. Angerhofer and T. Velusamy from the University of Maryland, USA, (Dr. Velusamy is permanently working with the Radio Astronomy Centre, TIFR, Ootacamund, India) have reported the result of radio and optical investigations of the supernova remnant CTB80 in the constellation Cygnus, (*Nature*, **284**, 1980, p 38). They obtained a map of the SNR CTB80 using the Westerbork Synthesis Radiotelescope with a beam size of 1^{m} x2^{m}arc at a wavelength of 49 cm and confirmed the presence of a bright compact object at its centre. This source is highly linearly polarised. Their initial guess about the age of the central object is that it is less than 10,000 years. The authors draw attention to the extended outer structures which characterise old SNRs.

They examined the photographic plate taken at the Mount Palomar Observatory which has SNR CTB80 in the field of view. There is an optical nebulosity which positionally coincides with the central source and has a similar extent. Angerhofer, A. S. Wilson and J. R. Maeld had earlier reported that the optical properties of the central source in the SNR CTB80 resembles that of 3C58, another young SNR with morphology similar to the Crab Nebula (*Astrophysical Journal*, **236**, 1980, p 143). Angerhofer and colleagues have estimated CTB80 to be about 10,000 light years away. The authors of both the papers cited have emphasised the relative youth of the central source of the supernova remnant CTB80.

Checking the compilation of "guest stars" recorded in Chinese chronicles, Strom and colleagues found references to a 'guest star', that could have been a supernova event, in the part of sky within 40° of the present position of CTB80. This guest star was seen around 24 October, 1408. It attained a brightness magnitude of about -3 (as brigat as Venus in the evening sky). This brings up the possibility that the SNR CTB80 could be a remnant of this SNE It fits in well with their earlier contention that the central source is a young object. Based on these observations, the hypothesis that the outer parts originated during activity before the SNE seen in 1408. So far, CTB80 is the only observed SNR with a young central source and extended outer features characteristic of an old SNR.

It is widely believed that pulsars are formed in SNEs. The outstanding example is that of the pulsar of period 33 millisecond in the Crab Nebula; this pulsar is a remnant of an SNE in 1054 which had also figured in the Chinese chronicles. An idea is also floating around that like Crab SNR, 3C58 also has a fast rotating neutron star embedded in it. It is of interest to look for a low period pulsar in the SNR CTB80.

DHIRENDRA MOHANTI

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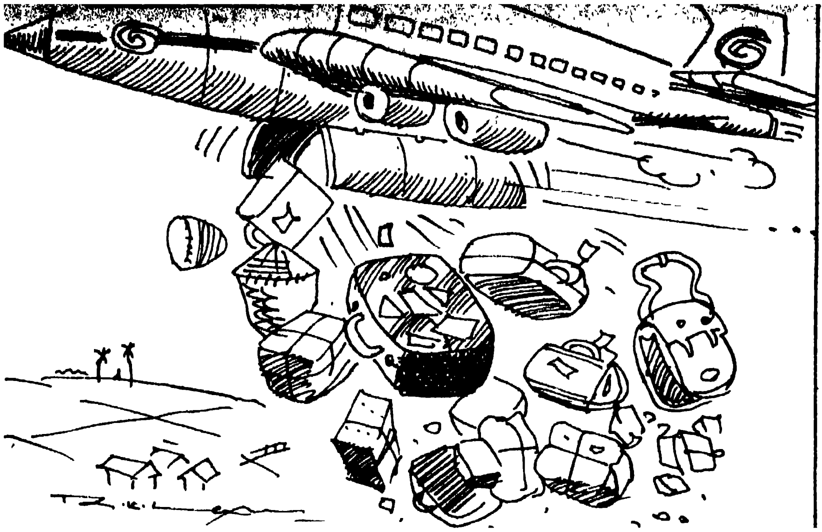
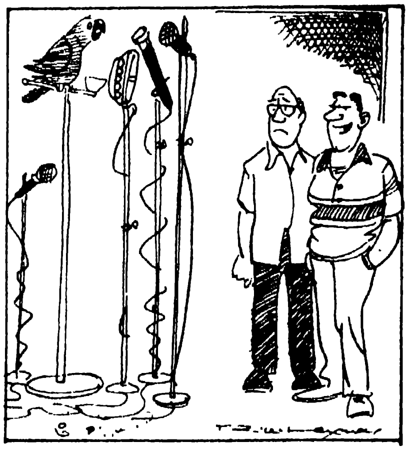


"No, no... this *button is for the music.*"

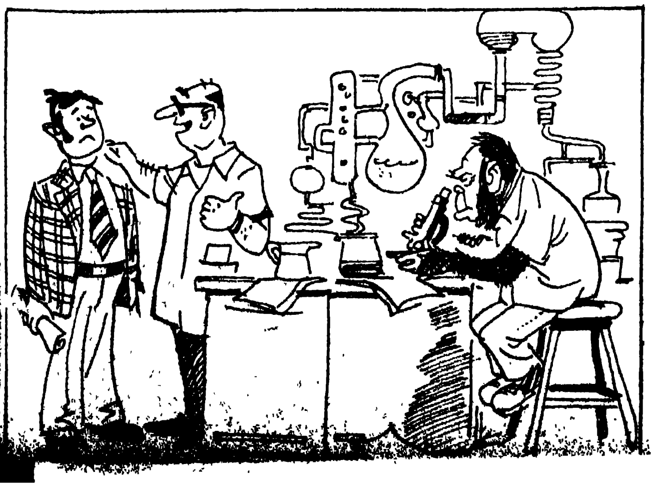
This World of Science!

by R.K. Laxman



"If he was human, he would have been in politics. The moment he learnt to speak he demanded mikes."

"Hot? Nonsense. Why, in the place I worked, the chief had made things hotter!"



"Young man, the conditions are excellent here. This chap was brought here for experimental purposes and today he heads the department!"

...and of Scientists!

GRAVITY was not always considered a unique and all-powerful law of nature as Newton and his admirers found it to be. The English botanist, T. A. Knight (1759-1838), showed by experiment that "centrifugal force by fast rotation" may prove to be superior to the greatest general law. In Knight's demonstration, seeds were made to sprout inwards ("from the outer ring of a quickly-spun wheel") the roots growing upwards—contrary to what usually happens in nature. The botanist had only used centrifugal force in the place of gravity. Acting as artificial gravity, centrifugal force proved even more powerful than natural gravity.

***

Le Corbusier

THE great architect, Le Corbusier, invented a new system of measuring in architectural activities, and named it 'modular'. He was very ambitious and over-hopeful about its success and worldwide acceptance. So he went to Princeton to get a certificate in its favour from Einstein. But the great physicist badly let him down saying, "The scheme would be quite satisfactory if it only serves to make the bad more difficult and the good easier".

***

Herschel

SIR WILLIAM HERSCHEL who doubled the dimensions of the known solar system by his discovery of a new planet Uranus, was also a celebrated maker of telescopes, along with his sister Caroline. Star-gazing became quite the fashion and many notables went in for astronomical telescopes. William Pitt paid a hundred guineas for one, though he was not able to make much of what he saw through it. King George III contributed £ 4000 towards the construction of one and delighted in showing off the instrument to visitors.

While it was still under construction and lying horizontally on the floor of the astronomer's house, the King went to see it, accompanied by the Archbishop of Canterbury. As they were inside the 12 metre long tube of the telescope, the Archbishop had some difficulty in walking and said so to Herschel who was just behind. Herschel said: "Come, my Lord Bishop, take my hand, I will show you the way to heaven"

S. N. MUNSHI

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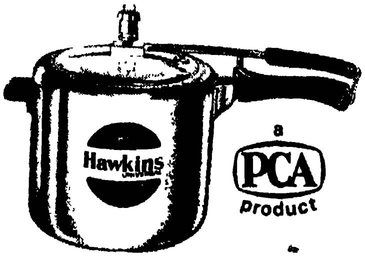

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China plans to gear up its science and technology

IT IS difficult to devise suitable neutral labels for the two major schools of thought which have been contending for supremacy in China since 1949. Purely for the sake of convenience, one may use the terms the Romantic School and the Realist School. Both these schools have been struggling to tackle some of the most complex and difficult and even seemingly unsolvable problems of social transformation in China. Efforts of *both* deserve serious study, and here we shall do so with reference to their science and technology policy contents.

Mao Ze Dong was indeed the fountain head of the Romantic School. So far as science and technology (S and T) are concerned, the notable elements of the ideas of this school are:

1. It underestimates the importance of S and T. This, of course, can be said only in a relative sense, but even so it does imply an important difference in emphasis.
2. It looks at the S and T elite (as indeed all types of elites) with a deep sense of distrust or even hostility.
3. In its enthusiasm for mass science, this school tends to downgrade the basic norms of quality of S and T work, both in teaching and research.
4. Finally, this school has a deep distrust of any attempt to learn from western scientists and technologists through a closer relationship with them or through technical collaboration arrangements.

Particularly, those who spent a lifetime of theirs in the environment of the Yenan culture were—and are even now—deeply committed to this view.

The Realist School, which is today led by the Hua-Deng team (and which, it appears, enjoyed the broad support of Zhou Enlai and Liu Shaoqi), takes an opposite stance. Even if in a relative sense, they lay a greater emphasis on S and T. They stress the inevitability and necessity of encouraging the building up of the S and T elite. They also advocate establishment of a close relationship with the West—including technical collaborations on a commercial basis—to learn from there.

From 1949 to around 1960, both the schools managed a reasonably comfortable co-existence. Then came the Great Leap Forward and the Sino-Soviet split. From that point, through the Cultural Revolution up to the last years of Mao, the Romantic School ruled supreme. This had disastrous consequences for China's S and T. To quote the impressions of Philip H. Abelson, editor of *Science*, who visited China in November 1978:

"The universities were closed in 1966, and classes were resumed only on a limited basis in 1970. At that time, the poorly qualified group of students were admitted who had been selected on the basis of ideological considerations. In contrast, earlier students were chosen on the basis of nationwide examinations.

"Attendance at universities was diminished to three years, with much of the time devoted to ideological and other non-academic matters. From 1966 to 1978, graduate school training was practically non-existent. The study and use of foreign languages were discouraged.

"We were told that in 1966 there were 100 research institutions, but that in 1976 only 40 remained."

After Mao's death in 1976, the Realist School, headed by Deng Xiaoping has been trying to bring about a basic shift in policy in many areas. And this shift is marked by the great crusade for modernisation in the four key areas—agriculture, industry, defence and science and technology.

The speech of Vice-Premier Fang Yi (who is also the Chairman of the Commission on Science and Technology) at the National Science Conference held in Beijing in March 1978, reproduced on pages 30 to 34, is an authoritative statement of the content of the proposed modernisation in relation to S and T.

This S and T Plan covers a period of eight years from 1978 to 1985. In refreshing contrast to the jargon-ridden style of most Chinese official documents, this speech is remarkably lucid and perceptive. Fang Yi gives a broad idea of what the Chinese hope to do in the eight key areas identified by them: (i) agriculture, (ii) energy, (iii) materials, (iv) computers, (v) lasers, (vi) space, (vii) high energy physics, and (viii) genetic engineering.

When this eight-year plan is completed by 1985, the Chinese expect to "approach or reach the advanced world levels of the 1970s in a number of important branches of science and technology, thus narrowing the gap to about ten years and laying a solid foundation for catching up with or surpassing advanced world levels in the following 15 years", that is, by AD 2000.

Even if it takes many more years, which it is certainly likely to take, the achievement of this goal would mark the historic transformation of China from a developing country to a developed country. What is significant is the setting of breath-taking goals in the area of S and T and the capability of the Chinese to mobilise themselves to achieve the goals.

Some of the proponents of appropriate technology may perhaps be unhappy with what they may regard as inappropriate emphasis on inappropriate technology in this plan. But the Chinese are obviously wiser than their admirers. They believe that "the small is beautiful but the big also is beautiful: and so we must have big and small both". This, in fact, has been their policy all along as it is today. The available data on production of China's big technology industries show clearly that the Chinese have never overlooked the big technology industries. In a sense, the acrimonious debates between the Romanticists and the Realists all these years have been only about the relative emphasis.

NAROTTAM SHAH

Dr. Shah is Director, Centre for Monitoring Indian Economy, Bombay

(see next page)

THE eight years from now to 1985 are crucial for the long-term goals of modernising agriculture, industry, national defence and science and technology, and placing the Chinese economy in the front ranks among the nations of the world. We must follow the message written by Chairman Hua for this conference: "Foster lofty ideals, set high goals and march toward the modernisation of science and technology." We must work out a strategic plan, fully mobilise all positive factors, and organise all our forces well.

Our plan should serve to bring about the four modernisations. The key to the four modernisations lies in the modernisation of science and technology. The whole Party, the whole army, and the people of all nationalities in our country are pinning high hopes on the speedy development of science and technology and demand that we make great contributions to the four modernisations. This is also the aspiration and determination of our comrades on the science and technology front. Our plan must be consistent with the needs of the four modernisations and the needs for developing our national economy and building our national defence. The plan on science and technology must dovetail with the plan for production and construction, and the two must be organisationally co-ordinated. Applied research and theoretical research and the immediate and long-term tasks must be properly arranged to avoid overemphasising one and neglecting the other.

Our plan should be aimed at rapid development. Compared with advanced world levels in science and technology, our country is now lagging roughly 15 to 20 years behind in many areas and still more in others. Only by developing at a higher speed can we catch up with or surpass the capitalist countries. We attained high speed by fulfilling five years ahead of schedule the major targets specified in the 12-year plan for the development of science and technology mapped out in 1956. In the mid-1960s we approached advanced world levels of the time in some scientific and technical spheres and made a number of outstanding achievements in science and technology which helped the popularisation of some new technologies and the establishment of some new, rising industries. Now that we have much better conditions and a much better foundation than in those days, attaining even higher speed is entirely possible.

Our plan should, moreover, be an advanced one with the present-day advanced levels as its starting point. We should conscientiously assimilate the experiences and lessons of our predecessors so as to avoid the twists and turns they went through. In carrying out the first plan for the development of science and technology, we worked in the correct direction by taking semi-conductor technology, which was an advanced field at the time, as our starting point for studying and developing electronic computers. As a result, we soon went beyond the stage of the electron tube and gained time. In the years to come, we should base our scientific research work in all fields on the mastery of the latest scientific and technological achievements and be courageous in breaking new ground. We must work hard to raise all our scientific research work to advanced levels as quickly as possible. The movement for scientific experimentation by the masses should also be steadily improved on the basis of popularisation.

Photographs published in Shanghai newspapers purport to show Chinese astronauts training for a launch in space

Since last June, departments under the State Council and various localities and units have done a great deal of work in drawing up the plan for the development of science and technology. A National Planning Conference for the Natural Science Disciplines was held in September and October last year, and a National Planning Conference for the Development of Science and Technology took place in December 1977 and January 1978. Through repeated discussions and revisions a draft "Outline National Plan for the Development of Science and Technology 1978-1985" took shape.

The draft outline plan sets forth the following goals in the next eight years.

1) Approach or reach the advanced world levels of the 1970s in a number of important fields of science and technology.
2) Increase the number of specialised scientific research workers to 800,000.
3) Build a number of modern centres for scientific experimentation.
4) Establish a nationwide system of scientific and technological research.

The eight-year draft outline plan makes overall arrangements for the tasks of scientific and technological research in 27 areas, including natural resources, agriculture, industry, national defence, transportation and communications, oceanography, environmental protection, medicine, finance and trade, culture and education, in addition to the two major categories of basic sciences and technology. Within these, 108 items have been chosen as key projects of national scientific and technological research. When this plan is fulfilled, our country will approach or attain the advanced world levels of the 1970s in a number of important branches of science and technology, thus narrowing the gap to about ten years and laying a solid foundation for catching up with or surpassing advanced world levels in all fields in the following 15 years.

The draft eight-year outline plan gives prominence to the eight comprehensive scientific and technological areas, important new technologies and pace-setting disciplines that have a bearing on the overall situation, namely, agriculture, energy resources, materials, electronic computers, lasers, space science and technology, high energy physics, and genetic engineering. It calls for concentrating all forces so as to promote the high-speed development of science and technology as a whole and of the entire national economy.

Science and technology in agriculture. Agriculture is the foundation of the national economy. Chairman Hua has given this instruction: "It is essential to undertake energetically research in agricultural sciences and change the present situation in which such research falls far behind the increasingly rapid development of largescale socialist agriculture".

In accordance with the principle of "taking grain as the key link for ensuring an all-round development," we will in the next three to five years actively carry out comprehensive surveys of our resources in agriculture, forestry, animal husbandry, sideline production and fisheries, study the rational exploitation and utilisation of the resources and the protection of the ecological system, and study the rational allocation of these research undertakings so as to provide a scientific basis for the all-round development of our country's large-scale socialist agriculture.

We should implement in its entirety the Eight-Point Charter for Agriculture (referring to soil, fertiliser, water management, seeds, close planting, plant protection, field management and improved farm tools) and raise our level of scientific farming so as to bring about a big increase in agricultural output. We should study and evolve a farming system and cultivating techniques that will carry forward our tradition of intensive farming and at the same time suit mechanisation. We should develop and manufacture farm machines and implements of high quality and efficiency. We should carry out scientific and technological research aimed at improving soils, controlling water, drastically changing the conditions of our farmlands and turning them into fields that give stable and high yields. In order to improve as quickly as possible the low-yield farmland that accounts for about one-third or more of the country's total, we must make major progress in improving alkaline, lateritic, clay and other kinds of poor soil, in preventing soil erosion, and in combating sandstorms and drought. We must study projects for diverting water from the south to the north and relevant scientific and technical problems. We must study and develop new compound fertilisers and biological nitrogen-fixation, methods of applying fertiliser scientifically and techniques for drainage and irrigation. We must cultivate new seed strains, develop new techniques in seed cultivation, and improve the fine crop varieties in an all-round way so that they will give still higher yields, produce better and more resistant seeds. We should quickly develop new insecticides that are highly effective and are harmless to the environment, and develop techniques for simultaneous prevention and treatment of different kinds of plant diseases and pests.

We need to step up scientific and technological research in forestry, animal husbandry, sideline production, and fisheries and promote an all-round development of these sectors. We should provide new tree seeds and techniques that will make the woods grow fast and yield more and better timber, develop multipurpose utilisation of forest resources, and study techniques and measures for preventing and extinguishing forest fires. We must step up research on building pasturelands, improving breeds of animals and poultry, mechanising the process of animal husbandry, increasing aquatic production, fish breeding, marine fishing and processing so as to make contributions to improving the elements of the people's diet.

We must set up modern centres for scientific experimentation in agriculture, forestry, animal husbandry, and fisheries and organise all departments and disciplines to tackle key problems by co-ordinated efforts and build up experience.

We must lay great emphasis on basic theoretical work in the agricultural sciences, step up our research in the application of agricultural biology, agricultural engineering and new technologies to agriculture, so as to lay a solid scientific foundation for constant innovations in agrotechniques and steady expansion of production.

Science and technology in energy resources. Energy resources are an important material basis for developing agriculture, industry, national defence, and science and technology and for improving the people's livelihood. Every major breakthrough in science and technology concerning energy resources has led to a revolution in production techniques. We must energetically accelerate the development of energy science and technology so as to carry on full and rational exploitation and utilisation of our energy resources and ensure sustained, speedy development of the national economy.

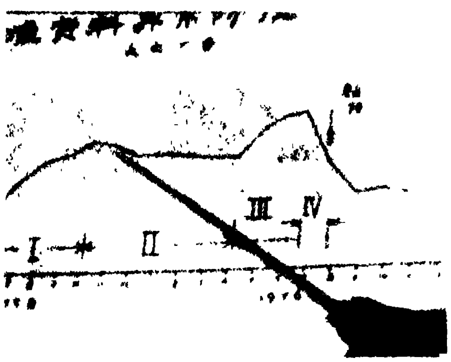
Foodstuffs being tested in a municipal health and epidemiological prevention laboratory

We have our own inventions in the science and technology of the oil industry, and in some areas we have caught up with or surpassed advanced levels of other countries. We must continue our efforts to catch up with and surpass advanced world levels overall. We should study the laws and characteristics of the formation and distribution of oil and gas in the principal sedimentary regions, develop the theories of petroleum geology, and extend oil and gas exploration to wide areas. We must study new processes, techniques, and equipment for exploration and exploitation and raise the standards of well-drilling and the rate of oil and gas recovery. We must actively develop crude oil processing techniques, use the resources rationally, and contribute to the establishment of ten more oilfields, each as big as Taching.

China has extremely rich resources of coal, which will remain our chief source of energy for a fairly long time to come. In the next eight years, we should basically mechanise the key coal mines, achieve comprehensive mechanisation in some of them, and proceed to automation. The small and medium-sized coal mines should also raise their level of mechanisation. Scientific and technical work in the coal industry should centre around this task, with active research in basic theory, mining technology, technical equipment, and safety measures. At the same time research should be carried out in the gasification, liquefaction, and multipurpose utilisation of coal and new ways explored for the exploitation, transportation, and utilisation of different kinds of coal.

We must come to grips with the salient contradictions of the electrical power industry. We should take as our chief research subjects the key technical problems in building large hydroelectric power stations and thermal power stations at pit mouths, large power grids and super-high-voltage power transmission lines. China has a great abundance of water power resources. We must concentrate our efforts on comprehensive research in such areas as the techniques involved in building huge dams and giant power-generating units and in geology, hydrology, meteorology, reservoir construction-induced earthquakes, and engineering protection which are closely linked with largescale hydroelectric power projects.

We should devote great efforts to exploring new sources of energy in order to change China's energy resource pattern gradually. Atomic power generation is developing rapidly in the world, and we should accelerate our scientific and technological research in this field and speed up the building of atomic power plants. We should also step up research in such areas as solar energy, geothermal energy, wind power, tidal energy, and controlled thermonuclear fusion. We should pay close attention to low-grade fuels, such as bone coal, gangue and oil shale and marsh gas resources in the rural areas, and make full use of them wherever possible.



Earthquake prediction is one area where the Chinese claim conspicuous success. Various types of anomalies are recorded to make a prediction

The techniques for the rational utilisation and saving of energy present an important problem that must be solved. People in all sectors should study this question, make full use of surplus heat, study and manufacture fine and efficient equipment for this purpose, try their best to lower energy consumption and particularly coke consumption in iron smelting, coal consumption in power generation, and energy consumption in the chemical and metallurgical industries.

Science and technology of materials. Painstaking research in this field is of paramount importance to the all-round modernisation of agriculture, industry, national defence and science and technology.

Steel must be taken as the key industry. Great efforts must be made to get a firm grip on metallurgical science and technology. It is imperative to make a breakthrough in the new technology of intensified mining and to solve the scientific and technological problems of beneficiating haematite so as to provide the iron and steel industry with large quantities of raw materials. We should speed up research work on the paragenetic deposits at Panzhihua, Baotou, and Jinchuan where many closely associated metals have been formed, solve the major technical problems in multipurpose utilisation, intensify research on the exploitation of copper and aluminium resources, make China one of the biggest producers of titanium and vanadium in the world, and approach or reach advanced world levels in the techniques of refining copper, aluminium, nickel, cobalt, and rare-earth metals. We should master modern metallurgical technology quickly, increase varieties and improve quality; study and master the laws governing the formation of high-grade iron ore deposits and the methods of locating them; and establish a system of ferrous and non-ferrous materials.

We should make full use of our rich natural resources and industrial waste and increase at high speed the production of cement and new types of building materials which are light and of high strength and serve a variety of purposes; step up research in the technology of mining and dressing non-metallic ores and in processing techniques; stress research in the technique of organic synthesis using petroleum, natural gas and coal as bases, step up our studies of catalysts and develop the techniques of direct synthesis, innovate techniques for making plastics, synthetic rubber, and synthetic fibres and raise the levels of equipment and automation in the petrochemical industry. We must make breakthroughs in key scientific and technical problems in producing special purpose materials, structural materials, and compound materials necessary for our national defence industry and for new technologies and develop a batch of new materials characteristic of China's resources.

We should devote great efforts to expanding basic research in materials science, develop new experimental techniques and testing methods, and gradually become able to design new materials with specified properties.

Electronic computer science and technology. Electronic computers are being used more and more extensively with far-reaching effects in scientific research, industry, agriculture, national defence, and social life. At present the electronic computer is developing in the following directions: giant computers, microcomputers, computer networks, and intelligence simulation. The scientific and technical level, scale of production, and extent of application of computers have become a conspicuous hallmark of the level of modernisation of a country.

China must make big advances in computer science and technology. In the next three years, we should rapidly develop basic research on computer science and related disciplines, lose no time in solving the scientific and technical problems in the industrial production of largescale integrated circuits, and make a breakthrough in the technology of ultra-largescale integrated circuits. We should produce experimentally giant computers, put a whole range of computers into serial production, step up research on peripheral equipment and software of computers and on applied mathematics, and energetically extend the application of computers. We aim to acquire by 1985 a comparatively advanced force in computer science research and build a fair-sized modern computer industry.

Microcomputers will be popularised and giant ultra-high-speed computers put into operation. We will also establish a number of computer networks and data bases. A number of key enterprises will use computers to control the major processes of production and management.

Laser science and technology. This is one of the most active branches of science and technology which began to develop in the 1960s. Its emergence, which marked a new stage in man's control and utilisation of light waves, has effectively promoted the development of physics, chemistry, and biology. Lasers have been widely used in materials processing, precision measurement, remote sensing, holography, telecommunications, medical treatment, and seed breeding. They have broad prospects in isotope separation, catalysis, and information processing. Laser-induced nuclear fusion is an important approach in exploring controlled thermonuclear reaction.

Applications of lasers

We will study and develop laser physics, laser spectroscopy, and non-linear optics in the next three years. We should solve a series of scientific and technical problems in optical communications, raise the level of ordinary lasers quickly, and intensify our studies of sensors. We expect to make discoveries and innovations in the next eight years in exploring new types of laser devices, developing new wave lengths of lasers, and studying new mechanisms of laser generation, making contributions in the application of lasers to studying the structure of matter. We plan to build experimental lines of optical communications and achieve great progress in studying such important applications as separation of isotopes and laser-induced nuclear fusion. Laser technology should be popularised in all sectors of the national economy and national defence.

Space science and technology. Space science and technology has been used in many aspects of the military, the national economy, and scientific research. The development of space science and technology is bringing about tremendous changes in earth sciences, astronomy and other disciplines. Space technology has raised such work as meteorological observation, survey of resources, environment monitoring, and cartographic survey to the level of concentrated automation. This not only saves large amounts of manpower and time but makes possible a timely collection of a greater wealth of data. As an information transmission centre, the man-made earth satellite can send messages directly to different places, thus causing radical changes in the technical system of communications, television, and radio broadcasting.

We should attach importance to the study of space science, remote sensing techniques, and the application of satellites; build modern centres for space research and systems for the application of satellites; step up the development of a series of launch vehicles, and study, manufacture, and launch a variety of scientific and functional satellites; actively carry out research in the launching of skylabs and space probes; and conduct extensive research in the basic theory of space science and the application of space technology.

High energy physics. High energy physics is a branch of science that studies the structure of elementary particles and the sublevel structure of matter and the laws governing their interaction. At present, new particles and new phenomena are constantly being discovered and theoretical research is continually deepening, bringing about new changes in high energy physics every day and making it one of the most active forefronts in the development of natural science in our time.

We expect to build a modern high energy physics experimental base in ten years, completing a proton accelerator with a capacity of 30 to 50 billion electron volts in the first five years, and a giant one with a still larger capacity in the next five years. Completion of this base will greatly narrow the gap between our high energy accelerators and advanced world levels.

We should from now on make full preparations for experiments in high energy physics, with particular stress on studying and manufacturing detectors and training laboratory workers. We should step up research in the theory of high energy physics and cosmic rays, consciously promote the interpenetration of high energy physics and neighbouring disciplines, actively carry out research in the application of accelerator technology to industry, agriculture, medicine and other spheres and pay attention to the important prospects of application.

The high energy physics experimental centre is a key project of the nation's list of scientific research centres, and it is necessary to organise the forces of all areas to build and use it jointly.

Genetic engineering. It is possible by genetic engineering, an outgrowth of molecular biology, to splice and transfer genetic substance at the molecular level and create new biological species to meet the needs of humanity. Genetic engineering provides an effective means of experimentation for such basic studies concerning higher organisms as cell differentiation, growth and development, and formation of tumours. It is likely to open new vistas for momentous changes in agriculture, industry, medicine, and certain other fields of production.

Genetic engineering is a new branch of study which appeared in the 1970s. Fast developing and highly explorative, it involves a wide range of disciplines and technologies, yet our country has only a rather weak foundation in this respect. Therefore, we must in the next three years strengthen organisation and co-ordination and step up the tempo of building and improving the related laboratories and conduct basic studies in genetic engineering. In the next eight years, we should combine them with studies in molecular biology, molecular genetics, and cell biology and achieve fairly substantial progress. We should study the use of genetic engineering in the pharmaceutical industry and explore new possibilities for treating certain difficult and baffling diseases and evolve new high-yield crop varieties capable of fixing nitrogen.

We must grasp firmly and effectively the above eight important spheres and organise all forces to tackle the major problems through a concerted effort. But this in no way means that we can neglect work in other spheres. We should take hold of the key spheres on the one hand and make overall planning and give all-round consideration on the other. Making overall arrangements while emphasising the key points — this is our policy.

Here I would like to mention in particular the matter of multipurpose utilisation. Chairman Hua has given this instruction: "We must attach importance to multipurpose utilisation which makes full use of natural resources and alleviates pollution of the environment. The three industrial wastes (liquids, gases, and solids) will bring harm if they are discarded but will become treasures if they are turned to good account." People working in all professions and enterprises should go in for multipurpose utilisation, and the sectors concerned should be organised to concentrate their forces on tackling major scientific and technical problems.

Learn advanced science and technology from other countries

Science and technology are the common treasure of mankind. All countries and nationalities have their own merits and characteristics, and exchanges can help them assimilate each other's strong points and blaze new trails. An important way to develop science and technology at high speed is to utilise fully the latest achievements in the world in science and technology and absorb their quintessence.

We should introduce selected advanced technologies that play a crucial and pace-setting role for modernising our country. We should take effective steps to assimilate the technologies introduced. Special teams should be organised to learn and study major scientific and technological items and complete sets of equipment that have been introduced. We should know the how and endeavour to know the why of the technologies introduced so as to create our own. We should study earnestly and conscientiously and grasp and understand the subject matter and then try to improve on it. We must not lightly criticise or discard anything before we know it inside out.

We must strengthen scientific and technical co-operation and scholarly exchanges with other countries and keep abreast of the results, trends, policies, and implementation of their scientific and technological research as well as their experience in organisation and management. We should actively and systematically enlarge the scope of sending scientific and technical personnel, students and post-graduates abroad to study, receive advanced training, make study tours, and take part in international scholarly conferences and other scholarly activities. At the same time, we will also invite foreign scientists and engineering and technical experts to China to give lectures, serve as scholarly advisors, or join us in scientific research.

Ensure adequate time for scientific research

Catching up with scientifically and technologically advanced countries means that we must narrow the time-gap between us and them. High speed means doing more work in less time. In this sense, time is the crucial factor, and we must seize the day and even the minute and the second. Mental labour is also a kind of labour, and a very hard one at that. Just as we must ensure full work hours for workers and peasants, so we must make sure that scientific research personnel can devote at least five-sixths of their time each week to professional work. We must exercise strict control over the practice of assigning scientific research institutions tasks that are irrelevant to scientific research. Research workers should be encouraged to study further on their own in their spare time, when they should be left free except for attending Party and Youth League meetings or engaging in other major political activities. A special effort should be made to study and solve the problem of ensuring an adequate number of work hours for the core research workers. They should be provided with assistants and their administrative duties cut down.

Guaranteeing adequate work hours for scientific research is an important political task for all scientific research institutions. Support services in scientific research institutions must serve scientific research, serve the front line in scientific research, and improve the living and working conditions of scientific and technical personnel. Our support workers in vast numbers are dedicated to their job, defy hardship and fatigue, and ignore extremes of weather. Their work goes into every achievement in science and technology. A close relationship of unity and co-operation, mutual help, mutual understanding and mutual encouragement should be established between scientific and technical personnel and the support workers. It is essential to create favourable conditions for work and study so that scientific and technical personnel can devote themselves entirely to the advancement of scientific research. Steps should be taken to improve canteens, nurseries, and other collective assistance facilities and the supply of equipment and materials. Because our country is not yet rich enough, it cannot possibly solve all the problems of material conditions at once. We can make improvements only gradually, while giving priority to certain key problems. At present, we should first of all improve the working and living conditions of scientific and technical workers who have made outstanding achievements.

Modernise laboratory facilities and information and library work

Modern natural science came into being only after the emergence of experimental science. Many important scientific results have been attained primarily because of the availability of new laboratory facilities. Advanced laboratory facilities are an important feature of scientific and technological modernisation.

In the next eight years, we should build a number of modern experimental facilities and centres. We should give a high priority to refitting the existing laboratories so as to modernise them as quickly as possible.

Emergency measures must be taken to push forward the designing and production of instruments and equipment. Efforts must be made to expand, renovate, and build a number of factories specialising in scientific instruments and chemical reagents. Scientific research institutions, universities and colleges should pay great attention to new principles, new techniques, and new products in their research on instruments and equipment and expand, where necessary, the capacity for processing, trial-manufacturing, and production.

It is essential to strengthen the management of the designing, production, distribution, and use of scientific instruments and bring them under an overall national plan. Costly, large precision instruments should be used jointly by units requiring them so that they are fully utilised. All large modern experimental centres should be open to scientific and technical personnel from organisations related to them and teachers and students from universities and colleges who come to conduct experiments and do research, so that these centres will gradually become research complexes.

With the development of science and technology, the number of scientific papers and data is increasing tremendously. Several million scientific papers and data sets are published in the world every year. If we fail to keep abreast of the directions, trends, and levels of achievement in scientific and technological development the world over, and waste our valuable human and material resources in following the beaten track and making the same zig-zags that others have made, it will be out of the question for us to catch up with or surpass advanced world levels in science and technology.

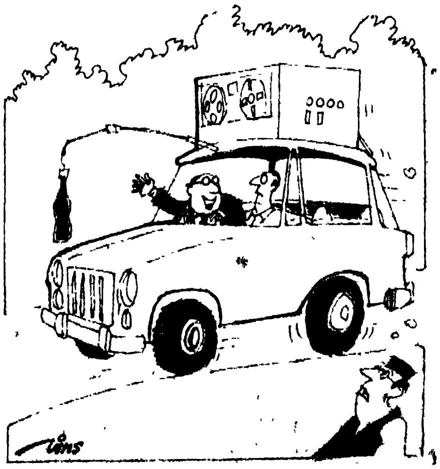
We should improve and strengthen our institutions for disseminating scientific and technical information and take effective steps to form scientific and technical information networks, based on regions and on fields. We should collect foreign scientific and technical information and data widely through many different channels. We should keep track of and organise information exchange of the research topics and scientific and technical results of our own research institutions. Scientific and technical administrative departments, institutions of scientific and technical information, and all scientific research organisations must improve their analysis and study of information.

It is essential to modernise scientific and technical information work and equip information institutions with modern facilities and equipment in the shortest possible time. In the next eight years we will set up a number of documentation retrieval centres and data bases and build a preliminary nationwide computer network of scientific and technical information and documentation retrieval centres. At the same time, we should strengthen the publication of scientific and technological documentation.

Make efforts to combine division of labour with co-operation

The Chinese Academy of Sciences is the overall centre for research in natural sciences throughout the country. Its main task is to study and develop new theories and technologies and to solve major overall scientific and technical problems involving many fields of economic construction, in co-operation with the ministries concerned. It should lay stress on basic theoretical research and aim at raising standards. The institutions of higher learning serve as centres of both education and research; they are an important force in scientific research, covering both the basic and the applied sciences. The research institutions of the various ministries and localities should devote themselves mainly to the applied sciences, but they should also undertake appropriate research in basic sciences. The above institutions and the mass contingent engaged in scientific experimentation should work in close co-operation with an appropriate division of labour.

We absolutely must develop the attitude of subordinating ourselves to the national interest. We must, first of all, ensure the fulfilment of the tasks assigned by the state and key projects, for this is where the overall interest lies. We must avoid diffusing our efforts and guard against the attitude of each going his own way. If every project claims priority, none can make a real advance, and this will be detrimental to the overall interest. We must give scope to the initiative of both the central and local authorities. Scientific research must be integrated with production and with applied work.



‘I knew it, fit a car with a computer almost human and it will run, just by the sight of pure alcohol.”

Practical approach

Monograph on Practical Examinations for Universities by V. Natarajan, Association of Indian Universities, New Delhi, 1979, 220 pp, Rs 9.

IT IS KNOWN to all persons familiar with our university education that we still persist with outmoded methods of teaching and evaluation of practical/laboratory/field work courses. A research project was undertaken by the author under the auspices of the Examination Research Cell of the Association of Indian Universities to make a detailed study of the situation in this regard and to suggest improvements. The book is an outcome of the research project.

Of the seven sections, the first is an introduction. The second section surveys the developments to date. Here data about practical work done in many universities from which information was solicited and received are presented. It is surprising to note that many 'prominent' universities have failed to furnish information in time. One does not find in the data a comparison of the weightages given to theory and practical work, which would have been useful. Section Three describes the aims and objectives of practical work. This section lacks clarity, because the author mixes the statement of objectives, which he considers important, with quotations from many other authors. (This is a typical practice in books on education.) Section Four analyses the responses of 81 teachers to an exhaustive questionnaire, painstakingly prepared by the author, which covers the scope, nature and design of practical work, its objectives, assessment methods, continuous assessment versus end examinations, and working versus grading. Although the sample is small, one can take it as representing fairly well the teaching community. It is gratifying to know that there is a wide consensus in the teaching community about the nature of the problem and ways of improvement.

The conclusions, presented in Section Five, are largely indisputable, although the discussion on working versus grading lacks conviction, especially in the context of rank orders needed in the large scale examinations conducted by various institutions in India for admission mainly to professional courses. Also, the issue of separate passing in theory and in practical work has not been considered. A bolder approach in emphasising the importance of continuous internal assessment *vis-a-vis* end examinations would have been welcome. One of the appendices describes model tests in a number of subjects. However, a test in physics should also have been included.

In spite of the 'awareness' of teachers, the problem defies solution, like many other problems of Indian education. Only, 'awareness' discussions and theorising alone are not enough; we need action and conscientious, action-oriented teachers. Pioneering efforts in physics laboratory courses have already been made at the University of Rajasthan physics department and at other places. While congratulating the author and the Association of Indian Universities in bringing out this useful monograph, one expects that they will be able to pool together the resources of some of the teachers and researchers in our educational system. The reviewers hope that their future publications will deal with concrete, tested ways of improvement.

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Banana mix-up

Fruit Physiology and Production by Amar Singh, Kalyani Publishers, New Delhi-Ludhiana, 1980, 513 pp, Rs 54.

ACCORDING to the author, this book has been written to fulfill the needs of a number of university horticultural courses, besides serving as a practical manual for pomologists, extension workers and others interested in all aspects of fruit production. But the subject matter covered is written in very general terms and does not meet the standards required for courses in horticulture even at the graduate level. The title itself is misleading, since emphasis on fruit physiology as related to pre-harvest and post-harvest factors has not been given its due share or discussed critically. Also, recent advances in post-harvest physiology and storage techniques for fresh fruits have not been covered adequately.

The book is in two parts. Part I attempts to cover a very broad spectrum of subjects related to fruit physiology and production in 14 chapters. This includes establishment and management of orchards, soil and cultural practices, propagation, weed and pest control, mineral nutrition, plant growth regulators, plant structure and fruit physiology. There is also a chapter on fruit preservation in fresh and processed forms. Part II (in 38 chapters) discusses the cultural and production aspects of 38 fruit crops. The appendix 'Fruit Trees at a Glance' is a repetition of the information already provided in Part II which discusses individual fruit trees.

Quite a few erroneous and ambiguous statements may be noticed throughout the book. The banana, for instance, is termed as a non-climacteric fruit (p.5), although it has subsequently been discussed as a typical climacteric type of fruit. On p.79, it is stated that, "Living matter called protoplasm is a viscous translucent mixture of complex materials. It may contain material like fat or starch which is non-living" (*sic*). Another instance is, "...parenchyma containing chlorophyll as in leaves and green stem is known as collenchyma..." (p.82). Similarly, on p.106, while discussing photosynthesis, it is stated, "the green plants have a marvellous energy producing process through the use of the pigment chlorophyll to transform sunlight into sugars and starch to begin with".

The chapter on fruit physiology lacks a critical appraisal of the current concepts and the significance of climacteric in fruit ripening and how harvest practices are governed by the class to which the fruits belong—climacteric or non-climacteric. The statement that "...climacteric fruits contain carotenoids and non-climacteric fruits contain anthocyanine" (p.214) is wrong. Inclusion of data on the proximate composition of nutritionally significant chemical constituents of fruits belonging to climacteric and non-climacteric groups at commercial harvest maturity and on ripening (in case of climacteric fruits) would have been informative to the reader. The temperature for the storage of green bananas (p.222) is given as 16° to 21°C, which should in fact be 12° to 13°C.

Apart from several such erroneous statements, the book contains many spelling mistakes.

The chapters on individual fruit trees could have been made more informative by providing the compositions of these fruits with respect to sugars, polysaccharides, organic acids, vitamins, etc at harvest or ripe, edible stages. Many readers may not be aware that tropical fruits like the banana, mango, guava, papaya, cashew, and pineapple are richer sources of calories, vitamin A precursors and vitamin C than temperate fruits like apples and pears.

One expects a much more critical and professional approach to the subject from a person who has been teaching post-graduate courses in agricultural botany for over 30 years. The 'selected references' lack the latest information on books, review articles and annual reviews, apart from important references in the concerned fields, especially in fruit physiology.

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Radiation protection in nuclear medicine

Pushparaja
T. Subbaratnam

The increasing use of nuclear medicine necessitates special precautions to protect people from radiation hazards

BORN in the 1920s, nuclear medicine is now a well-established branch of medicine in developed countries. Radiopharmaceuticals are used widely in medical diagnosis and therapy, as in scanning the brain, liver and thyroid, and in the treatment of cancer.

The demand for radiopharmaceuticals has been increasing steadily in India, and about 150 institutions now regularly use radiopharmaceuticals. The recent developments of generator-produced, short-lived radionuclides and radioimmunoassays will greatly increase this demand. And this rapidly rising medical use of radiopharmaceuticals is bound to create radiation protection problems for persons associated with nuclear medical procedures in clinics and hospitals.

Compared to conventional diagnostic methods, nuclear medical diagnosis has several advantages, the most important being the elimination of surgery for diagnostic purposes (SCIENCE TODAY, November 1974, p.29). Radiopharmaceuticals are compounds in which a suitable radioactive material is incorporated for medical use. These radionuclides can be easily traced in small amounts. They emit radiation, and as they circulate and get localised within the body, they can be traced and studied by radiation detecting devices placed outside the body. The radiopharmaceutical is usually given orally or intravenously and the radioactivity in the target organ can be measured by scintigraphy, which gives a two-dimensional picture of the organ. The radiation dose received by an organ will depend on the radioactivity administered, on the route of administration and on the functional uptake of the radiopharmaceutical by the particular organ. Any localised concentration of radioactivity within an organ may indicate the diseased part or a tumour.

Of all the therapeutic uses of radiopharmaceuticals, two are most prominent—the use of radioiodine in the treatment of frequently occurring types of thyroid cancer which cannot be removed by surgery, and the use of phosphorus-32 for the treatment of a certain rare form of cancer called "polycythenic vera". The dose concentration required for therapy is usually many times higher than that required for diagnostic studies.

Most of the radionuclides used earlier in nuclear medicine were produced in nuclear reactors (by activating suitable target materials followed by chemical processing) and decay by beta and gamma emission. Great efforts have been made in recent years to reduce the radiation dose to patients by using isotope generator or particle accelerator-produced short-lived radionuclides like technetium-99 m or indium-113 m or by attaching a long-lived radionuclide like iodine-131 to a suitable diagnostic compound that is rapidly excreted from the body.

The main radiopharmaceutical products in regular supply from the Radiopharmaceutical Section of the Bhabha Atomic Research Centre, Bombay (which is the sole supplier in India), can be broadly divided into three groups: (i) iodine-131 and its labelled compounds, (ii) short-lived radionuclide generators and radioimmunoassay and kits, and (iii) miscellaneous pharmaceutical preparations of phosphorus-32, chromium-51, mercury-203, cobalt-57, etc.

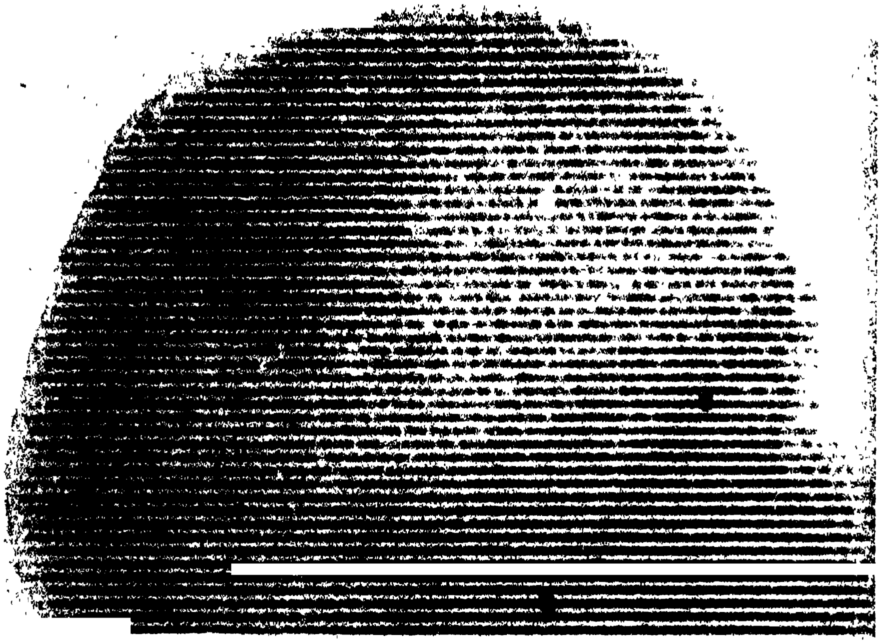
Iodine-labelled compounds are used to study the functioning of the thyroid, the lung, the liver and the kidney. Technetium-99 m and indium-113 m can be regarded as general-purpose isotopes; in their various forms, they may be used to visualise the thyroid, the brain, the liver, the spleen and the kidney. Other radionuclides of interest are chromium-51 for spleen scanning, selenium-75 for pancreas investigation and cobalt-57/58 for pernicious anaemia diagnosis.

Radiation safety aspects

Like all living organisms, man is exposed to radiation from a variety of sources, natural and man-made. Natural background radiation arises from sources like cosmic rays, the earth, and from radioisotopes like potassium-40 and carbon-14 present in the human body itself. An individual, on an average, receives about 100 millirems of radiation (see box on p.38) per year, depending upon his location compared to the sea-level. Man-made radioactive sources include radionuclides produced in nuclear reactors and radioactive fallout from nuclear weapons testing (strontium-90, caesium-137, etc).

Of the radiation received from man-made radioactive sources, med-

Image of a brain scan using a radiopharmaceutical



ical exposure alone contributes more than 90 per cent. Of this, again, X-rays contribute the most. Compared to diagnostic X-rays, exposure from nuclear medicine is not significant. Maybe nuclear medicine is now limited to a relatively small population, but its use is growing rapidly. And as its use increases, what is significant to remember is that the individual radiation dose adds to the total population dose. Hence, the public health and safety aspects of nuclear medicine need to be properly evaluated.

The current philosophy of radiation protection is based on the premise that any exposure to radiation at any level combines with it a certain amount of risk, small though it may be. One such effect is the ability of radiation to produce cancers of certain types, or carcinogenesis. In fact, human data on radiation effects have been obtained from studies of: (i) the incidence of lung cancer among uranium miners, (ii) a marked increase in the incidence of bone cancer in radium dial painters, (iii) children who had been irradiated while in their mothers' wombs for diagnostic purposes or detection of pregnancy, and (iv) a slightly higher incidence of leukaemia and skin cancer among radiologists.

Radiation effects are mainly classified as "somatic" and "hereditary"; somatic effects show up in the individual exposed, and hereditary effects appear in his descendants. Some of the effects are such that the probability of the effect occurring, rather than its severity, is proportional to the radiation dose. These effects are termed "stochastic" Since they appear even at very low doses, stochastic effects are held to be without a "threshold". There are other effects the severity of which varies with the dose and show a clearly defined threshold. These are termed "non-stochastic" Hereditary effects are generally considered to be stochastic. Some somatic effects like carcinogenesis are also stochastic. Non-stochastic effects are specific to particular tissues, for example, cataract of the eye lens, and non-malignant skin damage.

Table 1 Dose rate variance as [illegible] distance

Distance from source (m)	$\frac{1}{(\text{distance})^2}$	Exposure dose rate mR/hr
1		12800
10		128
30		14.2

Table 2 Approximate HVT and TVT values

Nuclide	Exposure rate constant, R mCi^{-1}hr^{-1}at 1 cm	Material, lead (cm)	
		HVT	TVT
Tc-99 m	0.76	0.3	1.0
In-113 m	1.77	1.0	3.4
I-131	2.04	0.7	2.4
Au-198	2.43	1.1	3.6

Radiation protection has two main aims—to prevent non-stochastic effects, and to limit the probability of stochastic effects to acceptable levels. To achieve this, the International Commission on Radiation Protection (ICRP) recommends dose-equivalent limits (DEL) for occupational exposure (persons who are exposed to radiation in the course of their work) so that the standards of safety and levels of risk associated with radiation work are comparable with other occupations which have high standards of safety.

To prevent non-stochastic effects in people occupationally exposed to radiation, the ICRP has recommended a DEL of 50 rems in a year to all tissues except eye lenses for which the limit is 30 rems a year. Dose limitation for the control of stochastic effects is based on the principle that the risk should be equal, whether the body is irradiated uniformly or otherwise.

Although the application of this system of dose limitation is a little complicated, in simple terms, it may be said that the DEL for irradiation of the whole body is five rems in any one year to prevent stochastic effects. These limits act as a check on proper and safe working practices. These DEL values, however, do not include radiation exposure from background sources or from intentional medical exposures.

Pregnant women run special risks from radiation exposure; the immature growing cells of fetal tissues are the most radiosensitive. Though an occupationally exposed woman of reproductive capacity (or suspected of pregnancy) working under the recommended DEL values, *delivered at regular rates*, is unlikely to receive more than 0.5 rem during the first two months of pregnancy, once pregnancy has been diagnosed, she should not be exposed to more than three-tenths of the annual DEL values, that is, during the rest of the months of pregnancy.

For the general public, the exposure limits vary. For an individual, the ICRP recommends a dose equivalent limit of 0.5 rem in one year to the whole body or effectively thereby—one-tenth of the DEL for occupational workers. This is based on several factors: (i) the general public comprises persons of various age groups, including children, pregnant women, sick and old persons, (ii) the exposure for occupational workers is voluntary, whereas for the general public, it is imposed on them, and (iii) the total risk due to radiation should be only a fraction of the similar risk due to natural causes.

The dose limitation system recommended by the ICRP demands that all exposure to ionising radiation should be justifiable in terms of net benefit, that any exposure so justified should be as low as reasonably achievable, and that the recommended DEL values should not be exceeded. Since people who enjoy the benefits derived

Units

Curie (Ci): A curie is a quantity of radioactive material which gives 3.7 x 10^{10} disintegrations per second (dps) or 2.22 x 10^{12} disintegrations per minute (dpm) 1 microcurie (μCi) = 3 7 x 10^4 dps. New unit: 1 Becquerel 1 dps.

Roentgen (R): Roentgen is the exposure dose of beta or gamma radiation. The corpuscular emission associated with one roentgen produces, in 0.001293 gm of air (1 c c of air at STP), ions carrying one electrostatic unit of electricity of either sign. It is equivalent to the absorption of 83 8 ergs of energy per gram of air.

Absorbed dose: Absorbed dose of any ionising radiation is the amount of energy imparted to matter by ionising particles per unit mass or irradiated material at the place of interest.

Rad: It is the unit of absorbed dose. 1 rad = 100 ergs/gm of absorbing medium. New unit: 1 Gray 100 rads = 1 Joule/ kg^{-1}

Rem (Roentgen - equivalent - man): Biological unit of absorbed radiation dose Rem is the dose of any radiation which produces the same biological effects as one roentgen of beta, gamma or X-radiation.

Dose equivalent: The absorbed dose is insufficient by itself to predict either the severity or the probability of the deleterious effects on health resulting from irradiation under unspecified conditions. In radiation protection, it has been found convenient to introduce a further quantity that correlates better with the more important deleterious effects, particularly with the delayed stochastic effects. This quantity, called dose equivalent, is the absorbed dose weighted by some modifying factors. The dose equivalent, H, at a point in tissue, is given by the equation, $H = DQN$, where D is the absorbed dose, Q is the quality factor and N is the product of all other modifying factors.

from nuclear energy may not be the same as those who suffer its deleterious effects, detrimental effects to any individual must be kept under check.

Yet, medical exposures are not controlled or guided by regulation or law, except that one is required to obtain a licence for using nuclear medical procedures. If judiciously used by the physician, the benefits of exposure greatly exceed the small risk to the individual. The physician decides about a procedure depending upon the investigation and his clinical requirements. Although the ICRP system of dose limitation is applicable to medical exposures, it is not appropriate to use these standards strictly for medical exposures if the individual receiving the exposure stands to benefit from the procedure. A higher level of risk may also be justified in some therapeutic procedures, but in such cases, it is desirable to consider alternatives and to compare their effectiveness and dangers with those associated with nuclear medicine procedure.

Facilities for medical use of radionuclides may consist of: (i) shielded dispensing facility, (ii) room for administration of diagnostic and therapeutic dose, (iii) storage of stock solutions and radioactive solid and liquid wastes, and (iv) decontamination facility, including a separate laundry for contaminated clothes.

The use of nuclear medicine procedures creates radiation exposure problems to the associated hospital staff and other patients in the adjoining beds. A major part of the exposure for associated medical staff comes from handling the radioactive preparations rather than from patients carrying radionuclide burdens.

External exposure results from any source of radiation external to the body, for example, an X-ray beam or gamma-emitting radionuclides like cobalt-60.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cobalt-57 (incorporated in vitamin B 12)	271	9.5	[illegible]	Liver
Cobalt-58 (vitamin B 12)	71	[illegible]	[illegible]	Liver
Gold-198 (colloid)	2.7	280	2.7	Spleen
Iron-59 (citrate)	45	600	[illegible]	Spleen
Indium-113 m (chloride/DTPA complex)	0.073	60	0.073	Kidney
Iodine-125 (iodide)	60	138	41.8	Thyroid
Iodine-131 (iodine)	8.04	138	7.6	Thyroid
Mercury-197 (neohydrin)	2.7	14.5	2.3	Kidney
Mercury-203 (neohydrin)	47	14.5	11	Kidney
Selenium-75 (methionine)	121	11	10.1	Kidney
Strontium-85 (chloride)	65	1.3×10^4	64.7	Bone
Technetium-99m (pertechnetate)	0.25	1	0.2	Total body

Time, distance and shielding are the three basic concepts which can be used to reduce external exposure. Reduction in the time spent in the vicinity of radioactive materials would reduce an individual's radiation exposure, the equation being,

Dose = Dose rate x exposure time.

Dose rate in milliroentgens per hour can be measured directly using radiation-sensitive instruments like radiation survey meters.

Increasing the distance between a source of radiation and an exposed person is another effective means of reducing radiation exposure. For a point source of radiation, the intensity varies inversely as the square of the distance from the source. Consider, for example, a point source of 1 millicurie of cobalt-60; the dose rate varies as a function of distance (Table 1). Radiation exposure can, therefore, be minimised by using remote-handling tools like tweezers and tongs.

Shielding is another important method. Lead, mild steel and concrete are the common shielding materials used to bring down radiation to safe working levels. The shield is erected in between the source of radiation and the exposed person. The thickness of the shielding material required to reduce the radiation exposure by a factor of 2 and 10 is called 'Half-value thickness' (HVT) and 'Tenth-value thickness' (TVT), respectively (Table 2).

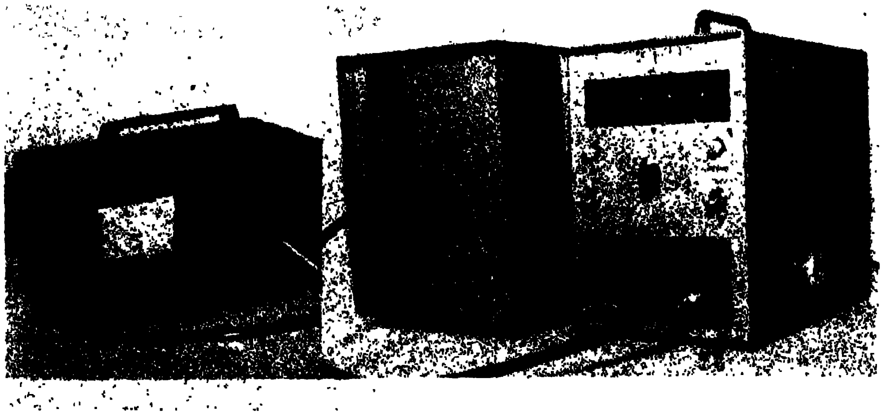
An internal radiation hazard exists when radionuclides enter the body by inhalation or ingestion. Depending upon its metabolism, the radiopharmaceutical will be utilised or deposited in specific organs. The tissue and the nearby organs are thus irradiated continuously until the material has decayed or has been eliminated by excretion.

Biological half-life can now be defined as the time taken for the 50 per cent elimination of the nuclide from the body by biological means. From internal hazards point of view, however, effective half-life (T) is of considerable importance and is given by

$$T = \frac{1}{Tr} + \frac{1}{Tb}$$

where Tr is the radioactive half-life of the nuclide, and Tb the biological half-life. Biological elimination of radionuclides can be enhanced by administering stable isotopes of radionuclides which are not radioactive and which dilute the radioactive isotopes (for instance, iodine-131 is

Some of the instruments developed by the Directorate of Radiation Protection (DRP), Bhabha Atomic Research Centre, Bombay, for use in hospitals using nuclear medicine procedures. Clinical dosimeter (left) and isotope calibrator (right)



diluted by stable sodium iodide) and/or use of complexing agents like ethyline diamine tetra acetic acid (EDTA).

Radionuclides should be administered to patients only under the responsibility of a highly motivated physician who has been trained in the use of radionuclides. He must be aware of the radiation safety methods in nuclear medicine procedures.

Reduction of dose

There are several ways by which exposure to patients could be reduced. One of them is the selection of suitable radionuclides for diagnostic purposes. Radiopharmaceuticals having shorter effective half-life in the organ of interest will reduce patient dose considerably—for example, technetium-99 m which has a half-life of six hours instead of iodine-131 (half-life eight days) for thyroid scan. Short-lived isotopes can be substituted for longer-lived radionuclides for the same clinical test: I-125 for I-131, Hg-197 for Hg-203 and Co-57 for Co-60. Generator-produced metastable nuclides (see later) decay by either isomeric transition (IT) or by electron capture (EC). These radionuclides generally have short half-lives and the absence of particulate emission (absence of beta and alpha ray emissions) reduces the local radiation dose to a large extent. For a typical thyroid scan, the radiation dose absorbed by the thyroid in millirad per microcurie administration of I-131, I-125 and Tc-99 m is about 2000, 1000 and 0.3, respectively. This shows the usefulness of generator-produced radionuclides.

The most important advantage of cyclotron-produced radionuclides is the low radiation dose associated with those which have a very short half-life. They are especially useful in investigations involving children and pregnant women. Examinations can be repeated without interference from background activity from previous examinations. Cyclotron-produced radionuclides are also available in carrier-free form (high specific activity). In India, the production of some of these radionuclides is likely to be taken up at Calcutta by the Radiopharmaceutical section of the Isotope Group, BARC.

Usually, the effective half-life of generator or cyclotron-produced radionuclides is almost the same as its radioactive half-life. Thus the major portion of the administered activity is promptly excreted resulting in the delivery of the highest absorbed dose to the bladder. With the longer-lived radionuclides, the organ that concentrates the radionuclide may receive the highest absorbed dose.

The knowledge of minimum activity required to carry out a particular test will help reduce the dose. The amount of activity required to be administered will vary depending on factors like half-life, energy of emission and the nature of clinical information sought. With the availability of short-lived isotopes, millicurie amounts of the short-lived radionuclides can be used for diagnostic studies. Also, the actual concentration of the activity of the radiopharmaceutical should be rechecked before it is administered to the patient.

Table 4 Some of the generator-produced isotopes and their annual intake limits (ALI)

Nuclide	Disintegration type	Gamma radiation main energies (million electron volts)	ALI (μ Ci) (ingestion)
Sr-87 m	IT (99.4%) EC (0.6%)	0.388 (78%)	57,000
Tc-99 m	IT (100%)	0.14 (90.1%) 0.142 (0.04%)	57,000
In-113 m	IT	0.39 (65%)	11,000

* ALI is the annual intake limits for soluble materials, calculated from the data for maximum permissible concentrations of drinking water and air for radiation workers given in ICRP publication 2

Table 5 Some of the cyclotron-produced radionuclides in current medical use

Nuclide	Half-life	Principal radiation (MeV)	Chemical form and use
F-18	100 min	β^+,γ 0.511	Carrier-free in neutral aqueous solution (localisation studies)
Fe-52	8.2 hr	β^+,γ 0.165 0.511 1.434	Ferric citrate (investigation of bone marrow)
Ga-67	78 hr	0.093 0.184 0.296	Gallium citrate (localisation studies for soft tissue tumour)
Ga-68	68 min	β^+,γ 0.511	Gallium - EDTA (localisation studies)
I-123	13.3 hr	γ 0.159	Sodium iodide (thyroid function studies)

Other methods of reducing radioactive exposure include the use of blocking agents wherever possible so that only the organ of interest is exposed to radiation (the use of chemical compounds which block the entry of radioactive isotopes into non-target organs); the use of most sensitive and fast scanners which can reduce the activity required for an investigation considerably; avoiding repeat examinations as far as possible (when a repeat examination is carried out, the physician should ensure that there is no activity remaining in the body from the previous test and if it is there, it also should be taken into account); and review of the technique for each procedure using radionuclides from time to time, with an assessment of the availability of new and improved equipment or a better radiopharmaceutical.

Exposure of the nuclear medicine technologist and his staff can be kept at a minimum level by following these regulations:
(i) the use of personnel protective clothing like overcoats and hand gloves while handling radioactive materials, (ii) the use of syringe shields and remote pipetting devices (a 3-mm lead shield for the syringe can easily reduce the finger/hand dose by a factor of ten), (iii) all radioactive solutions that are not in use should be adequately shielded and stored in a suitable place, (iv) radioactive materials should be handled expeditiously and with due care; it is desirable to distribute the radioactive work load so that a single person is not exposed all the time, and pregnant nurses should not be responsible for the routine care of patients with appreciable radioactive burdens, (v) the concept of minimum time and maximum distance should be followed while dealing with a patient who has taken a diagnostic or therapeutic dose, and patients should be encouraged to take care of themselves and nursing should be kept to the minimum, (vi) area monitoring and monitoring for personal contamination should be carried out routinely, especially after every handling of radioactive material, (vii) personnel monitoring devices like film badges and dosimeters should be used to record the radiation exposure received by working personnel and any consistently higher exposure revealed in film badge reports must be investigated. However, in no way does the film badge or the dosimeter afford protection from radiation, but it only records the radiation exposure

of the wearer. Besides, all radioactive liquid wastes (washings, excretions and vomit of the patients) and solid wastes (syringes, glassware, gloves, etc) should be collected and properly disposed of. Disposable syringes, needles and glassware will avoid radiation exposure from cleaning and decontamination. Alternatively, the contaminated glassware and syringes can be allowed to decay for sometime (8 to 10 half-lives) and then reused. (viii) autopsy or post-mortem of the body containing radioactive material should be delayed, if possible, until the activity has reached an acceptable level. The usual precautions, including the use of special gloves, should be taken. No special precautions are necessary in the case of cremation of corpses containing up to 30 mCi of I-131 or Au-198 or 10 mCi of P-32 because of their short half-life and the nature of radiation emission.

Recent developments

Radioimmunoassay (RIA) is one of the recent developments in radiation medicine. RIA is an extremely sensitive, rapid and specific radiometric estimation (in vitro) of trace levels of biologically important ingredients like hormones, vitamins, steroids, etc. Samples of various body fluids are drawn and tests are conducted on these samples; patients receive no radiation dose at all. These RIA procedures are of great help in thyroid function studies, early diagnosis of diseases related to insulin, and for determining the levels of human placental lactogen (HPL) in pregnant women to identify risk/abnormal pregnancies.

Usually I-125 is used for labelling the protein hormones in a suitable enclosure. Decomposition of such labelled molecules can liberate I ions which remain in solution and, under certain conditions (like higher acidity), the radioactive iodine may escape from RIA tubes. Hence the test-tubes should be tightly capped and kept under suitable temperature conditions. Discarded assay tubes should be stored carefully in a well ventilated atmosphere. Air-borne iodine activity can be estimated by sucking the laboratory air through a charcoal impregnated filter paper or charcoal (activated) pack for a fixed time. Iodine will be adsorbed on the charcoal and can be measured in a scintillation counter. Knowing the amount of air passed through the filter paper/charcoal pack, iodine concentration in the air can be estimated.

Generator-produced radionuclides

A generator ('cow') is a device which separates efficiently and in a pure form a short-lived daughter isotope existing in nuclear equilibrium with a long-lived parent isotope. An elution or milking technique is used to separate the daughter element from the parent element—for example, technetium-99 m, which has a half-life of six hours from molybdenum-99, which has a half-life of 67 hours, and indium-113 m (half-life, 1.7 hours) from tin-113 (118 days). Technetium and indium are the two important short-lived isotopes produced by the generator.

These generators should be designed such that the exposure to the operating technician should be minimum. The generators should be housed in a well-ventilated fume hood or a modified cross-flow laminar, clean air work station depending upon the design of the generator and the activity handled with sufficient shielding. Much of the exposure occurs during the setting up of the generator, milking the generator, calibration and dispensing the doses, and injection. During the operation of a generator, hands and eyes are more exposed than the whole body.

The exposure to eyes and whole body can be considerably reduced by the use of leadglass body shield where the view is not affected. Since the diagnostic dose is of the order of millicuries, care should be taken during injection of scanning agents. Because of the bigger doses used, occupational radiation exposure of the personnel will be increased by the use of these short-lived radionuclides compared to conventional diagnostic procedures using microcurie amounts of longer-lived radionuclides. Normally the index finger receives the highest dose. Estimation of personal exposures during the entire operation can be made using thermoluminescent dosimeters (disc-type) fastened to a band-aid type applicator, and locating them at different parts of the body.

Typical instruments used to detect radiation and to control radiation hazards. Radiation survey meter (left) and monitor (right)

Cyclotron-produced radionuclides

Cyclotron is a device which accelerates charged particles and heavy ions in a constant magnetic field to high energies. These particles may be directed to collide with specific target materials. The production of isotopes using high energy particles is more versatile than reactor production, especially for radionuclides that are neutron-deficient and decay by electron capture with the emission of X-rays or by positron emission with accompanying annihilation radiation. Because of the very short half-life, absence of beta-emission, and directional radiation to aid location in scanning, these radionuclides of high specific activity are potentially important in nuclear medicine. The main disadvantage of these cyclotron-produced radionuclides is that the patient must be brought to the hospital attached to the cyclotron facility, while in the case of generators, portability is the main advantage.

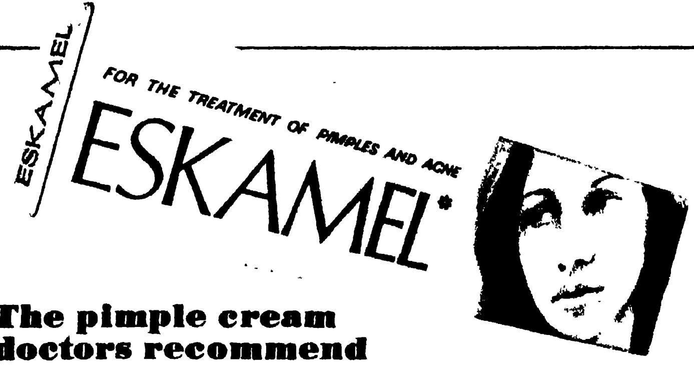
Dr. Pushparaja, who obtained his PhD in chemistry from Bombay University, is scientific officer in the Health Physics Division, Bhabha Atomic Research Centre, Bombay He has been working on radiation hazards control for 12 years. At present he is doing research in separation chemistry in the University of Ottawa, Canada, on a post-doctoral fellowship.

Mr. Subbaratnam heads the Radiation Hazards Control Section of the Health Physics Division at BARC, and is responsible for radiation protection in all installations under the Department of Atomic Energy He has been working in the field of radiation protection for the last 28 years, specialising in the design of laboratories, safety analysis of large nuclear installations, etc.

Choose the pimple cream that not only treats pimples but helps prevent pimple scars

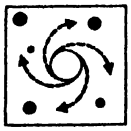
ESKAMEL*

pimple cream

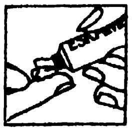


The pimple cream doctors recommend

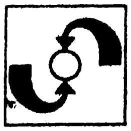
If you are not careful, pimples can leave behind unsightly scars. You can help by not touching pimples (even if you're itching to!). And by using Eskamel—the pimple cream that treats pimples and helps prevent pimple scars.



Hands off! Pimples spread if pricked, scratched or touched.



Apply Eskamel over your face with damp cotton wool.



Eskamel has two proven ingredients that check infection, reduce skin oiliness and dry up pimples fast.

SK&F A Smith, Kline & French product.
*Eskamel is a Regd. Trade Mark.

LINTAS-ESK.2-2518

Handy letter-weighing device

How many times, after writing a long letter, or after stuffing enclosures along with it in the same envelope, have you posted it with misgivings that it may have been under-stamped? Alternatively, you have to rush to the nearest post office during working hours, stand in a queue patiently and get the letter weighed. All this could be avoided with a handy letter weigher.

In offices where a number of letters are posted daily, a common balance made of brass or stainless steel, with pans and weights, is used for weighing. It gives accurate readings, but is cumbersome to operate. Modern offices use a weighing scale, but even this is too bulky. What we want to know, in fact, is not the exact weight of the letter but the right postage needed. The postage is usually specified in 5 gm steps and so it is enough if the readings are taken in 5 gm steps.

The present weighing devices are not designed specifically for letter weighing and hence they are not wholly suitable for this simple operation, apart from their cost. People do not post merely from offices and post offices but also from railway stations, airports, hospitals, factories,houses and so on. Hence, the need is for a compact and more convenient letter-weighing device—one which could be carried perhaps in one's pocket—of modest cost and suitable for modern offices and modern houses. These are the kind of considerations behind a letter-weighing device designed at the National Institute of Design, Ahmedabad, as part of a students' project.

The new device is nothing more than a simple circular plate of plastic, of the size of a palm. It follows the principle of moving fulcrum type balance, using its own body-weight as a counter to the object weighed. Different fulcrum points are located on the circular body of the plate, which is graduated from 5 gm to 50 gm, which is the usual requirements for letters. At each fulcrum point there is a pin with a head where one can hold the device and lift. At one side of the circular plate there is a spring grip to attach the letter to be weighed. There is a horizontal line across the circular plane of the plate. The approximate weight of the letter is known by simply attaching the letter to the spring grip at one side of the device and then lifting the device by holding one of the pins marked at 5 gm steps, till the line stays horizontal. When the line remains horizontal the marking at that particular fulcrum point indicates the weight of the letter attached.

There are hardly any complicated parts, hence the device would cost no more than a stapler, a file punch and other devices of the work table. It needs no loose weights. It could be attractively finished in a wide range of plastic colours. It could also be used as a paper weight in offices and on the tables of the executives. It is handy and can be easily carried in the pocket.

The device has been calibrated with a standard weighing machine using standard weights. It is fairly accurate. The user can clearly mark the weight of the letter within 5 gm.

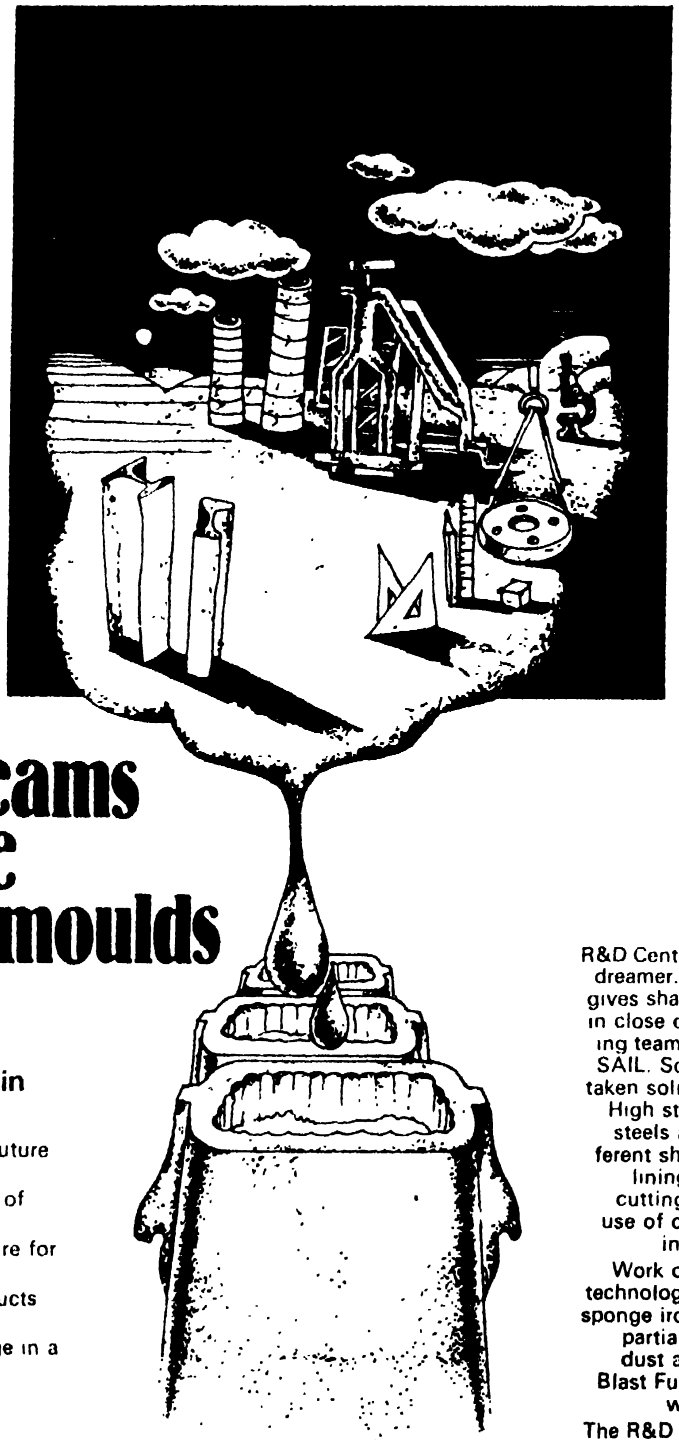
The body material is polypropylene which is inexpensive as well as durable. The calibration could be easily made by silk screen printing. The holding pins are made of stainless steel and fixed to the plate.

No weights needed, can be carried about in the pocket...

The production method is very simple and suitable for both small-scale industrial production as well as large-scale mass production. The device could be produced by turning on an ordinary lathe for batch production or with a small plastic injection moulding machine for mass production. A few prototypes were made and tested at NID very successfully. The cost of production would be about Rs. 10 a piece.

S. BALARAM

Mr. Balaram is Chairman, Extension Programmes, National Institute of Design, Ahmedabad.



When dreams are cast in moulds

It means fulfilment for our researchers in steel making.

- To expand facilities for future development.
- To enhance the potential of existing strengths
- To create the infrastructure for systematic growth
- To provide superior products and processes
- To serve humanity at large in a more purposeful way

It is necessary to dream. And analyse, experiment, evolve, innovate.

The Research and Development Centre of SAIL is engaged in such a task A new thrust has been imparted in work relating to increase in productivity, reducing production costs, improving quality, developing new grades of steel and improving profitability. Every man engaged in SAIL's R&D Centre at Ranchi is basically a dreamer. He thinks, innovates and gives shape to his dreams working in close collaboration with operating team in the steel plants under SAIL. Some of these dreams have taken solid shape. Development of High strength low Alloy (HSLA) steels and rolling them into different shapes, improvement of LD lining life, computerised billet cutting operations to herald the use of on-line computers in steel industry are some of them.

Work on developing indigenous technology for direct reduction for sponge iron using non-coking coal, partial briquetting of coal, lime dust and coal dust injection in Blast Furnace are some others on which work is in progress.

The R&D Centre of SAIL strives to cast dreams in steel. For betterment of national economy. For betterment of humanity.

STEEL AUTHORITY OF INDIA LTD.
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Research & Development Centre Hinoo, Ranchi.

CA-D-S/R&D-1

How much do you know about MICROBIOLOGY?

The naked human eye misses a whole world of wonderful microbial life. Microbiology and its many related sciences are advancing so rapidly that much of the 'jargon' has crept even into the newspapers today. This month's quiz lists 20 common terms from microbiology. Tick the word or phrase *nearest in meaning* from the three alternatives given with each After that turn to the next page and see how close your guesses were.

1. **Flagella:** A: Tongue-like appendage seen on microbe. B: Locomotive appendage seen on microbe. C: Stinging organ of microbe.

2. **Diatom:** A: Dried remains of bacteria. B: Minute microbe made up of only two atoms. C: Alga with silica-containing cell walls.

3. **Procaryote:** A: Cell with no definite nucleus. B: Any parasitic organism. C: Alga with silica-containing cell walls.

4. **Bacteria:** A: Any sub-microscopic organism. B: All rod-shaped micro-organisms. C: Ubiquitous microbes with no defined nucleus.

5. **Mycology:** A: Branch of science dealing with microscopic parasites. B: Branch of botany dealing with fungi. C: Branch of zoology dealing with unicellular organisms.

6. **Fungus:** A: A tufted bacterium. B: Filamentous organisms lacking chlorophyll. C: Any spiral microbe.

7. **Aerobe:** A: Organism that requires air to survive. B: Organism that does not require air to survive. C: Bacteria that can live without oxygen.

8. **Virus:** A: Minute infectious organism. B. Nucleated bacteria. C: Name of a drug used to cure bacterial diseases.

9. **Pasteurisation:** A: A heat-aided preservation technique. B: A chemical preservation technique. C: Preservation technique that uses low temperature.

10. **Clone:** A: Bacteria of the same subspecies. B: A sexually produced individual from single cell. C: A freak microbe.

11. **Spore:** A: Resistant body formed by certain microbes. B: Reproductive cell. C: Bacterial colony.

12. **Gram's stain:** A: A measure of microbial size. B: Laboratory method for differentiating bacteria. C: Method for staining blood cells.

13. **Biodegradable:** A: Capable of being broken down by micro-organisms. B: Micro-organisms incapable of surviving in water. C: Capable of killing any life-form.

14. **Rickettsiae:** A: Bacteria possessing some characteristics of viruses. B: Germs that cause rickets. C: Bacteria that cannot survive in sunlight.

15. **Antibiotic:** A: Growth-inhibiting substance produced by micro-organisms. B: Toxin produced by virus. C: Toxin produced by bacteria.

16. **Abiogenesis:** A: Incapable of genetic transmission. B: Life form whose origin is unknown. C: The generation of life from non-living substances

17. **Biological shield:** A: Migration-preventing structure for living organisms. B: Flat multicellular organism. C: Preventive for bacterial diseases.

18. **Salmonella:** A: Germs responsible for common cold. B: Germs responsible for diarrhoea and other diseases. C: Germs responsible for leprosy and other diseases.

19. **Protozoa:** A: A type of nucleated micro-organism. B: A group of bacteria. C: A type of unnucleated micro-organism.

20. **Mitochondria:** A: Intracellular structures seen in the cytoplasm. B: Structures seen in the nucleus of cells. C: Structures seen in cell walls.

Ideas and Inventions

Contd. from p 43

cess consists of hydrolysing sawdust, newspaper waste and other cellulosic materials to a glucose-rich syrup. The hydrolysis is done continuously in the barrel of a plastic extruder, originally designed to process plastics. The cellulose is fed to the extruder with water where it is mechanically broken up. Excess water is removed; the temperature is raised to about 250°C and a pressure of 35 kg per sq cm is applied. Just before the material is ejected from the machine, weak sulphuric acid is added to trigger a reaction that almost instantaneously converts cellulose into glucose. Because the acid is added at the end of the process, damage to the extruder is minimised. Other routes for converting cellulose to glucose have been reported earlier, but these suffer from low reaction rates and batch production. The present technique is continuous, has low space requirements and high reaction rates.

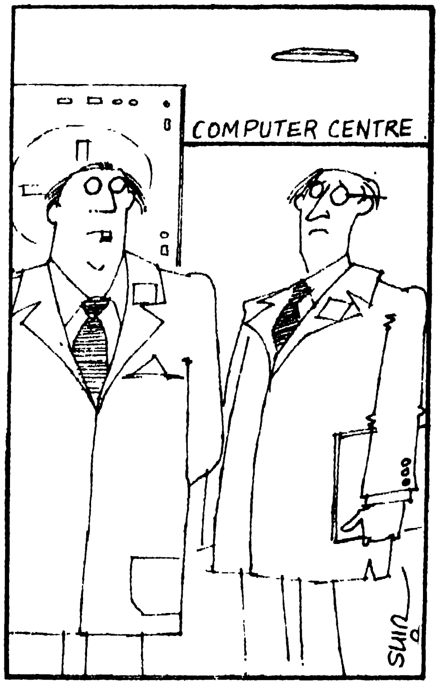
Utilisation of coal to manufacture industrial chemicals has some limitations. One of the components of gasification is carbon monoxide which reacts under severe conditions to form several chemical products. Metal carbonyls are used as catalysts.

A process for the production of acetic anhydride, using methyl acetate and carbon monoxide as starting materials, has also been reported. The process is an extension of acetic acid production from methanol and carbon monoxide. The process requires temperatures of 150° to 200°C and a few atmospheres pressure. The acetyl complex so formed could be decomposed to alternative products. Acetic acid would give acetic anhydride, water would give acetic acid, hydrogen and acetic acid would give ethylidene diacetate which, on pyrolysis at 120°C on an acidic catalyst, would yield vinyl acetate.

Possibilities of operating the plant to produce vinyl acetate with acetic acid, acetaldehyde and acetic anhydride as co-products offer much commercial potential.

V. C. MALSHE

Dr. Malshe is research officer at the ACC Research Centre, Bombay.



"Hey, that's no way to treat it Don't order it by saying, 'if you don't perform at your peak no new tapes for you' "

PEEPING TOM!

The Answers

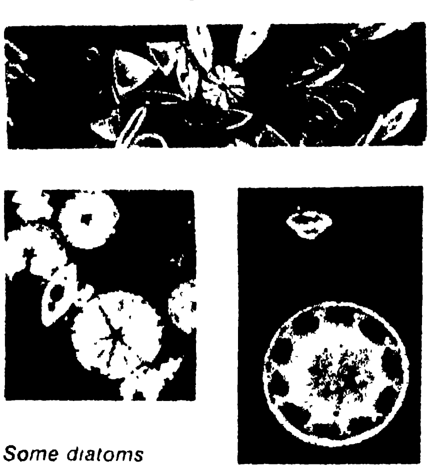
1. Flagella—B: The filamentous locomotive appendages seen on certain micro-organisms. Flagella are fine and hair-like, much less than 0.1 micron thick (1 micron = 10^{-6}m) and several microns long. On a bacterium, the flagella originate either singly or in tufts at one or more points. Bacteria without flagella cannot swim. The bacterial flagellum is akin to the flagellum of animal sperms, protozoa and the male gametes of many lower plants.

Under an electron microscope, these have an outer plasma membrane and a matrix of eleven fibrils (microtubules) arranged longitudinally. Microtubules are made up of a long chain of polymeric aggregates of a protein called tubulin.

Flagellation may be of different types, single, double, or in tufts

2. Diatom—C. The common name for alga of the class Bacillariophyceae. These algae have silica in their cell walls. Diatoms have long been a favourite with naturalists because of the beauty and symmetry of their siliceous cell walls. With their endless diversity of patterns, they abound in all natural waters and are the basic food for many organisms.

Past deposits of countless diatoms have formed what are called diatomaceous earths, used in making dynamite, for filtering and absorbing liquids and in the paint industry. Also, oil reserves of diatoms of the past ages have contributed to the petroleum supplies of today.


Some diatoms

3. Procaryote—A. Any cell with an undefined nucleus, such as the bacteria and blue-green algae. These cells lack internal membranes, including nuclear membranes. The genetic material in these cells is in the form of simple filaments of DNA, not separated from the cytoplasm. The cell walls of the procaryote are unique in that they contain *mureins*, distinctive polymers composed of certain amino-acids and carbohydrates.

Cells with a definite nucleus, on the other hand, are described as 'eucaryotes'

4. Bacteria—C: Relatively simple procaryotic (see *3*) micro-organisms found almost anywhere on earth. A gram of soil may contain from a few thousand to several million bacteria. So with a millilitre of milk. The bacteria have a practical significance for man. Some cause disease in man, animals and plants, thereby affecting his health and economy. Three principal shapes of bacteria exist—spherical (cocci), rod-shaped (bacillus) and spiral shaped (spirillum). Many bacteria are not mobile and just drift with air or water currents. Of the motile bacteria, some move by means of flagella (see *1*).

Some bacteria are the source of certain antibiotics (see *15*).

5. Mycology—B: Branch of botany deals with the study of fungi. Medical mycology is a specialised field concerned with fungi that cause disease.

Various fungi are used in industrial processes like brewing and baking. The development of antibiotics from fungi, particularly penicillin from pencillium, has enhanced the importance of mycology.

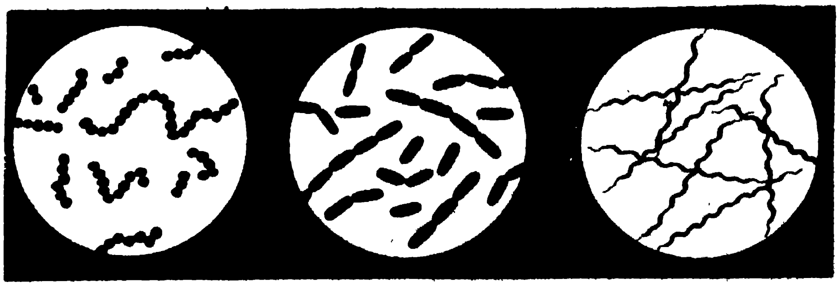
6. Fungi—B: Nucleated, usually filamentous and often multicellular organisms devoid of chlorophyll. They are not differentiated into roots, stem and leaves like the higher plants, and range in size from single-celled microscopic yeasts to giant multicellular mushrooms and puffballs. Microbiologists (and in particular, mycologists) have special interest in those organisms commonly called moulds, mildews, yeasts and the plant pathogens known as rusts.

Fungi reproduce by fission, by budding or by means of spores.

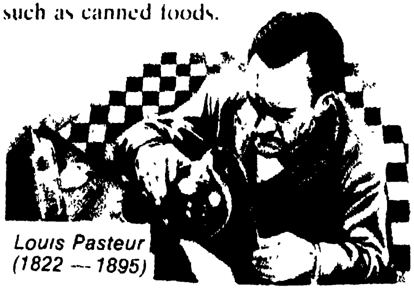
7. Aerobe—A: An organism that requires air or free oxygen to maintain its life processes. Most forms of life require oxygen for respiration, without which they perish. There are certain microbes (anaerobes) that can do without oxygen, and others that find oxygen positively harmful because they lack the enzymes that transfer hydrogen to free oxygen (like the absence of the enzyme catalase resulting in the inability to breakdown toxic H_2O_2) Microbes of the genus *Clostridium*— responsible for diseases like botulism, gangrene and lockjaw—are strict anaerobes.

8. Virus—A. A large group of minute infectious agents, sometimes as tiny as 300 millimicrons in diameter, composed of a protein sheath surrounding a nucleic acid core. Viruses are characterised by total dependence on living cells for reproduction. They lack independent metabolism.

Almost all forms of life are susceptible to viral infection, including man, animals, plants and even bacteria (bacteriophages). Viruses have been responsible for countless diseases since antiquity, causing so many ailments ranging from the common cold and influenza to smallpox, and infectious hepatitis.


Some common types of bacteria. Left to right: streptococcus, typhoid bacillus and Treponema pallidum

9. Pasteurisation—A: The application of mild heat for a specific time to a liquid food or beverage to enhance its keeping properties by destroying any harmful micro-organisms present. Pasteurisation originated with Louis Pasteur in the 1860's, who demonstrated that spoilage of wine and beer could be prevented by heating these beverages to approximately 135°F (57.2°C) for a few minutes. Today, all dairies routinely pasteurise milk. Pasteurisation, however, does not kill all organisms or spores (see *11*). Sterilisation, on the other hand, kills all germs and spores, and therefore, no bacterial spoilage can occur in properly sterilised foods, such as canned foods.


Louis Pasteur (1822 — 1895)

10. Clone — B: In its most common usage, a clone refers to the genetically identical descendants of a single cell produced by asexual cell division. The term is also used to describe groups of plants or animals which derive their genetic component from a single parent through tissue culture techniques or animals genetically descended from a single parent through parthenogenesis (the development of an individual from an egg without fertilisation), or through the development of an egg whose nucleus has been replaced by the nucleus of a donor of the same species.

In recent years, genetic engineering techniques have permitted the production of multiple copies of single genes or gene groups.

11. Spore—A. A uni- or multicellular, asexual, reproductive or resting body that becomes detatched from the parent and is resistant to unfavourable environmental conditions. The spore produces a new vegetative individual when the environment is favourable.

Bacterial spores

12. Gram's stain—B: A differential staining technique widely used in bacteriology as one of the criteria for the identification and classification of bacteria. This technique has introduced an artificial division among bacteria, making them either gram-negative or gram-positive.

13. Biodegradable—A: When something is described as biodegradable, that means it is capable of being broken down by micro-organisms. For example, cellulose—a complex sugar—contained in grass is broken down by the micro-organisms present in the cow's rumen before it is digested. Many undegradable plastics have to be treated in order to make them biodegradable. Biodegradable detergents are very much in demand today because they do not accumulate in streams or rivers, but get decomposed by micro-organisms. Recently bacteria have been genetically engineered to biodegrade oil spills and plastic wastes.

14. Rickettsiae—A: Named after H. T. Ricketts, who discovered them in 1909, the rickettsiae have some properties of bacteria and some of viruses. Although formerly classified as intermediate between bacteria and viruses, they are now recognised as procaryotic (see *3*) micro-organisms and classified as bacteria. They often cause diseases in humans, particularly typhus fever.

15. Antibiotic—A: Chemical substances produced by using organisms that have the capacity in low concentrations to inhibit the growth of and even destroy bacteria and other micro-organisms. Penicillin was the first antibiotic to receive widespread attention. Since then, over 2,000 other antibiotics have been identified or synthesised.

16. Abiogenesis—C: The obsolete concept that plant and animal life can arise from non-living organic matter. Abiogenesis is also known by other terms like autogenesis and spontaneous generation.

Abiogenesis has an interesting history. About 40 BC, Vergil gave directions for the artificial propagation of bees. Many other such fanciful beliefs were entertained right up to the 17th century, for example that maggots could be produced by exposing meat to warmth and air. But this was soon disproved. Even after the discovery of microbes, this idea persisted for a time, but Louis Pasteur's experiments ended the debate about spontaneous generation for all time.

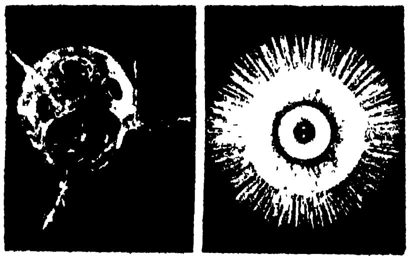
17. Biological shield—A: A structure designed to prevent the migration of living organisms from one part of a system to another. Biological shielding is often used on sterilised space probes.

Biological shielding becomes very important in experiments involving pathogens or recombinant DNA experiments where potentially hazardous gene combinations may arise.

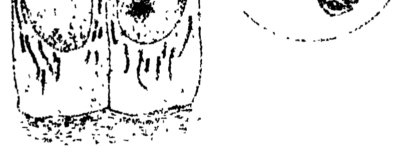
18. Salmonella—B: A genus of gram-negative (see *12*), rod-shaped pathogenic bacteria of the family Enterobacteriaceae. The salmonella cause infections in man and other animals with or without blood invasion. Varieties of salmonella cause such diseases as diarrhoea, gastroenteritis, enteric fever and typhoid. The diseases caused by salmonella are collectively called salmonelloses.

19. Protozoa—A: A group of eucaryotic (see *3*) micro-organisms, traditionally classified under the animal kingdom. Although the name signifies primitive animals, some protozoa show enough plant-like characteristics to justify claims that they are plants.

Protozoa are almost as widely distributed as bacteria. The free-living types occur in soil, wet sand and in fresh and salt waters. They range in sizes from less than two microns to a few centimetres.


Glass models of some marine protozoa

20. Mitochondria—A: A cytoplasmic structure seen within cells. Mitochondria, when examined under a microscope, may appear as small spherical granules, short rods, or long filaments. The number of mitochondria varies greatly with the type of cell and with the site of its physiological activity. A liver cell, for instance, will contain some 1,400 mitochondria. Mitochondria are the sites of cell respiration, and contain highly integrated enzyme systems providing energy for cell metabolism, hence often called a cell's 'rechargeable batteries'



Mitochondria are often referred to as a cell's rechargeable batteries'

M.S.

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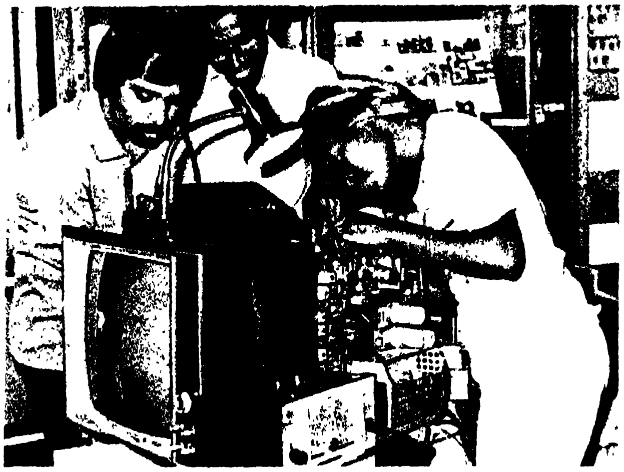

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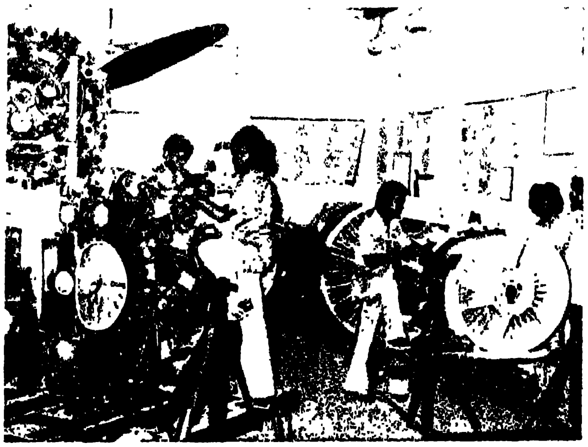

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... time could run backwards

A GOOD deal of science fiction is based on the proposition of time running backwards or of people travelling into the past. But is such a thing possible? Why does time show a marked preference for going in one direction?

Let us first see what would happen if events ran backwards in time. One possible way would be to make a movie of any natural phenomenon and then run it backwards. Some of the events will appear to violate natural laws, in some others, only the usual convention will be reversed, but the rest of the phenomenon will look indistinguishable from those of the normal conditions.

To exemplify, all creatures, including human beings, will grow younger in age. A man will begin to take shape from a mere handful of his own ashes and will ultimately return to the womb, animals will start inhaling carbon dioxide and giving out oxygen, our stomachs will act as cooking pots rather than digesters, cooking vessels will produce the ingredients which went into them and refrigerators will work hard to maintain the room temperature. Curd, sweets, ghee, etc will effortlessly degenerate into milk. An object lying below a cliff will feel highly insecure. Water will naturally tend to flow upwards. The earth's atmosphere will produce high energy cosmic rays. And so on.

Some examples of the second group will be cars appearing to run in reverse, the sun rising in the west, the hands of a clock running counterclockwise, the lines of a page beginning from the right, the ideas leaving one's mind, etc. In these examples, one may notice that merely the convention has been reversed; the fundamental laws of nature operative behind them remain unchanged.

It is the third group of events which is truly time-reversible. For example, if we press the button of a machine, it will be "on" as it used to be earlier. If we throw a ball, it will first go up and then come down. A current-carrying conductor will bring about the right deflection in a magnetic needle, according to the same version of Ampere's rule. Two colliding bodies will share their momenta and their energies will accord with the theory. In fact, due to such time reversal no basic law of mechanics, electricity, magnetism and gravitation would suffer from any change in its theoretical structures, except perhaps in the domain of particle physics where, so far, the one and only instance of the violation of this time-reversibility has been recorded about 15 years ago.

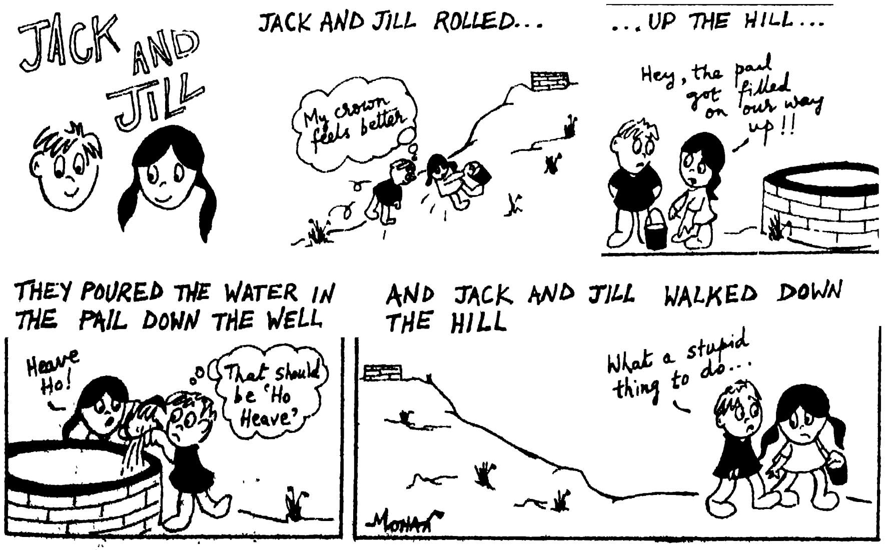
However, the way in which we have tried to realise this transformation cannot be extended indefinitely. Because, in an actual time-reversal transformation, the rays of light and radiation would also reverse their direction of travel. (When we try to project the cine film, the reversal of light tracks is not at all ensured.) So if we take that into account as well, the sun will appear as a perfect sink of thermal radiations. In fact, every source of radiation will then behave as a sink of radiation. Heat will effectively flow from a colder to a hotter body. And, the entropy of any closed system will decrease with time and work will have to be regarded as the degraded form of heat. Atoms also will spontaneously absorb radiation rather than emit it.

So the concept of time-reversibility leads to a contradiction as far as reality is concerned. Nature, it seems, prefers the flow of time to occur in one particular direction and clearly not in the other. This has brought the concept of 'the arrow of time' into the realm of physics. Time always points its arrow towards the future and the distinction between the past and future rests on the spontaneity of the becoming (evolution) of a system. The fact that radiation always spreads out from a source with some delay in time depending on the distance of propagation gives rise to what is called the electromagnetic arrow of time and the fact that the heat is always transported from a hotter region of space to a colder one just to achieve a state of thermal equilibrium (this is also a motive of nature) leads to a second arrow of time, namely the thermodynamic arrow of time.

In order to elucidate the thermodynamic arrow of time, we consider here a typical example in some detail. Let an apple fall on the ground. In reality, this event finds an easy explanation even at the molecular level. The apple is a lump of molecules, each of which is vibrating vigorously due to its internal store of energy in the form of heat; also, each molecule shares a certain amount of gravitational potential energy due to its specific position with respect to the earth. Now, the moment the apple is released, each and every one of the constituent molecules gains some kinetic energy in the form of coherent motions of individual molecules, of course at the expense of the potential energy. As soon as the apple hits the ground, the collective motion of the centre of gravity is lost altogether to reappear in the increased vibrational energy of the molecules pertaining to the ground as well as the apple.

What is time?

Unlike matter, time is not an independent entity. It is merely a concept that emerges out of the status of evolution of any system including the universe as a whole. If there are no phenomenal changes in the state of a system in any form whatsoever, the concept of time is bound to lose its meaning altogether. In nature, we find systems evolving spontaneously and we characterise their evolution by an abstract parameter called time. Keeping pace with such self-induced evolutionary manifestations, this parameter runs without stop, while the concept of the "present" remains eternally frozen. The measure of time is nothing but the co-ordinate of this ever-running "present" in terms of the above parameter. Every instant that elapses, the present moves a bit ahead, engulfs the future and merges with the past. And in course of such evolution, every system passes through a definite sequence of states. The connecting thread, being apparently ensured by causal relations, leads to the apparent flow of time in a particular direction, namely from the past to the future.


JACK AND JILL
JACK AND JILL ROLLED...
My crown feels better
...UP THE HILL...
Hey, the pail got filled on our way up!!
THEY POURED THE WATER IN THE PAIL DOWN THE WELL
Heave Ho!
That should be 'Ho Heave'
AND JACK AND JILL WALKED DOWN THE HILL
What a stupid thing to do...
MOHAN

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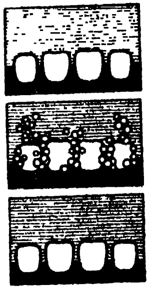

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[illegible] certain amount of work energy becoming degraded into heat and then diffusing outwards in such a manner that it seldom finds an opportunity to be concentrated again in a small body like the above apple. Or, in other words, the statistical probability of such a happening (down to the molecular level) is very small; once something ordered gets shuffled or disordered, it is highly improbable that the original order will be restored in a larger scale. This is exactly what happens in its time-reversed version, which demands that a certain amount of heat (in the form of vibrational energy of the molecules constituting the ground and the apple) gets accumulated on the interface of the ground and the apple so suddenly that it produces an explosion without violating the laws of conservation of energy (the first law of thermodynamics) and momentum (another basic law of physics). And this explosion should impart a huge momentum to the apple that subsequently follows the very same laws of the projectile motions. If we carefully analyse all such macroscopic but natural events that seem absurd in a time-reversed framework, we will discover that it is the second law of thermodynamics that is violated allowing heat to be spontaneously converted into work. So the second law of thermodynamics imposes the so-called thermodynamic arrow of time and a sequence of events can be ordered according to the spontaneity criterion of natural evolution which can distinguish between past and future somewhat absolutely.

The electromagnetic arrow, on the other hand, has a conceptually different origin. Any propagation of light or radiation in vacuum should be describable in terms of the solutions of Maxwell's equations. But Maxwell's equations are so perfectly time-symmetric that both the retarded and the advanced types of solutions (discussed below) are equally admissible. Here, the retarded solution corresponds to outward propagation of radiation from any source with some delay in time, depending on the distance of the place under consideration. For example, the state of solar radiation that we analyse here on the surface of the earth at a given instant should depend on some related affairs that took place on the surface of the sun about 500 seconds earlier. (This is the time taken by light signals to travel the distance between the sun and the earth.) But the advanced solution, on the other hand, implies an inward propagation of radiation that tends to converge on to the source right at the moment of excitation. As we recede from the source, the incoming wavefront has to pass through that point earlier in time. So the advanced solution corresponding to our solar example represents an incoming wave that has to cross the earth's orbit around the sun about 500 seconds earlier than what induces it as a prime cause, namely the process of de-excitation of the solar atom. The latter seems absurd and hence, we claim, nature has selected the retarded solutions (and has rejected the advance ones.) For that it has also adopted certain causal orders in the associated events, even though the Maxwell's equations admit both type of orderings. This is how the electromagnetic arrow of time has become an indispensability.

There is, in fact, a third arrow of time, namely the cosmological arrow of time. The universe is expanding, and, as a result, the galaxies seem to recede from each other with time. The spectra of distant sources of radiation appear to be red-shifted. If time could run backward, it would certainly imply that the universe is contracting and, furthermore, the background of the sky would appear to be extremely bright, at least as bright as the stars and galaxies are. Since the universe in reality does not look like the latter type, the existence of this third kind of arrow of time is justified.

However, some scientists believe that these three arrows of time are not all that independent. Theoreticians like John Wheeler, Richard Feynman, Fred Hoyle, Jayant Narlikar, Thomas Gold and others have argued in favour of such connections. If they are right, then we have to admit that it is so because the universe expands, radiations spread out from a lamp after it is lit (otherwise incoming radiations would advance in a way to converge at the lamp before it is lit) and perpetual machines of the second kind are an impossibility. In fact, any one of these three statements necessarily implies the other two, as the above mentioned scientists try to prove with great zeal. So if the universe be a closed one, it will one day start its phase of contraction and a sudden flip in the arrow of time will also become imminent. And, therefore, time can run backwards, in principle, at least

Now, one may ask whether it is possible to travel into the past while living in this expanding universe. If tachyons that travel faster than light in vacuum do exist, and if they can carry some information, at least in the form of signals (the apparent non-local behaviour of some quantum system may alternatively favour such an idea), the answer could possibly be in the affirmative. But then in certain cases, the causal structure of the events will break down. For an illustration, let us suppose that we have got a suitable time-capsule which is capable of taking us into the past You then meet your great great grand mother and see her dead long before you see her get married. The result would disastrously affect your very existence too! However, we could, in principle, go backward in time to meet events that are causally disconnected from the very threads we belong to.

N.C. RANA

Mr. Rana is with the Tata Institute of Fundamental Research, Bombay.

Awards and Appointments

Kalinga Prize for popularisation of science

THE Kalinga Prize for 1980 has been awarded to Prof. Hounar von Ditfurth of West Germany. Prof. von Ditfurth, who was once a teacher of psychiatry and neurology, is Director of a psychopharmacological laboratory in Germany. Prof. von Ditfurth was selected by a UNESCO international jury for his several articles on scientific topics as well as innumerable radio and television programmes. The prize carries with it the UNESCO medal, a sum of £ 1,000 and a visit to India.

The Kalinga Prize, instituted in 1952, had been earlier awarded to several distinguished winners who include Louis de Broglie, Julian Huxley, Bertrand Russell, Jean Rostand, Konrad Lorenz and Margaret Mead

Nayudamma

COSTED Chairman

PROF Y NAYUDAMMA has been appointed Chairman of the Committee on Science and Technology in Developing Countries (COSTED). Prof Nayudamma, at present Distinguished Scientist at the Central Leather Research Institute, Madras, was formerly Director-General of the Council of Scientific and Industrial Research, New Delhi.

The COSTED is one of the committees under the International Council of Scientific Unions.

Dr. M.S. Swaminathan

DR M S SWAMINATHAN has been appointed acting Deputy Chairman of the Planning Commission

Dr. Swaminathan, an agricultural scientist whose research interests are extensive, was until recently Secretary, Ministry of Agriculture.

Swaminathan

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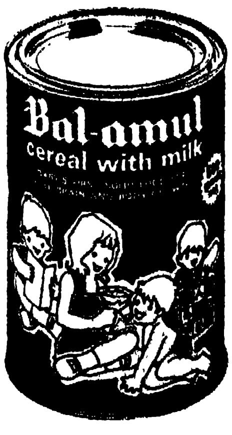

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Sexual differences in the brain

Arthur P. Arnold

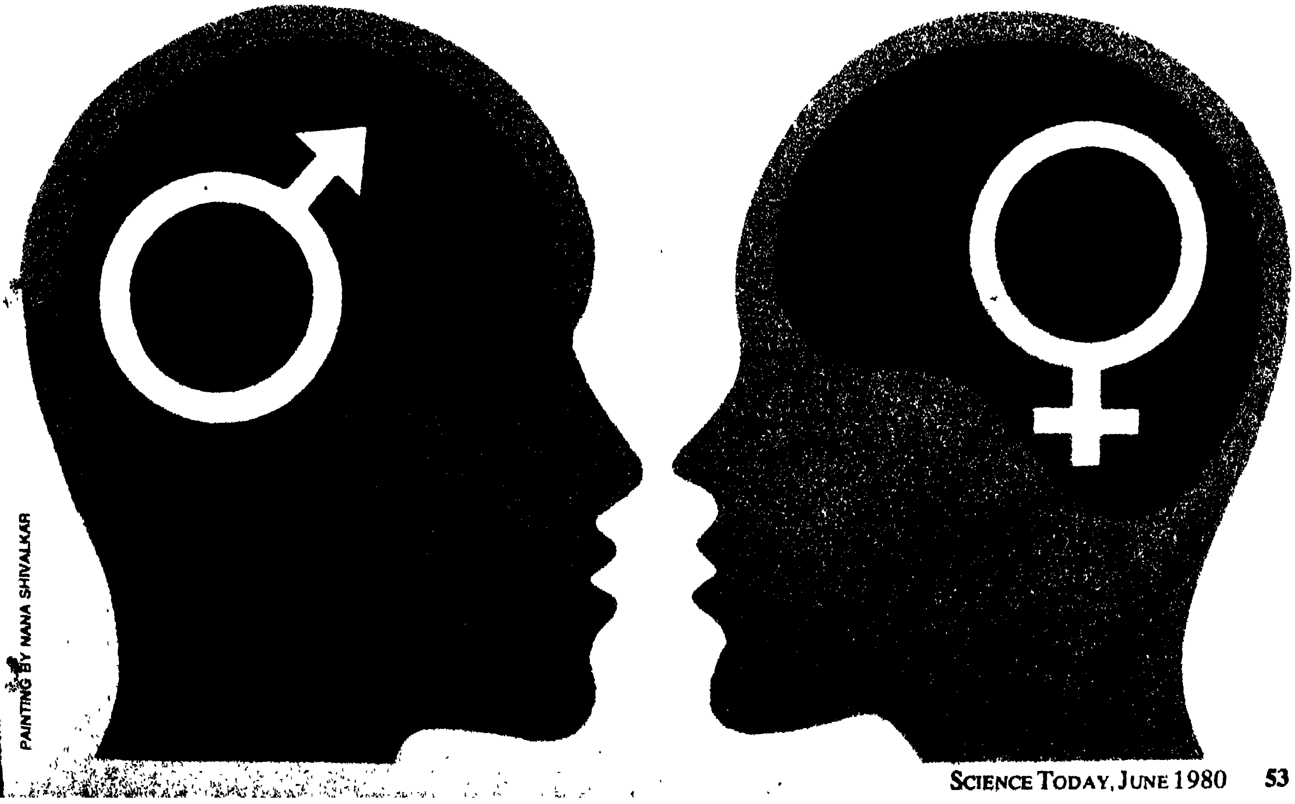
Marked physical differences in brain regions concerned with sexual functions provide new insight into the roots of sex differences in behaviour

ONE OF the most basic observations we make about human behaviour is that men and women are different. Those of us who observe animal behaviour are also immediately impressed with sex differences, especially in behaviour patterns which are important in reproduction. For example, parental care is frequently performed predominantly by one sex: in red-winged blackbirds, the females look after the young, and in South American rheas, this is the duty of the male. What are the roots of these sex differences in behaviour? It is important to try to identify genetic, physiological, and environmental factors that determine whether an animal will act in a masculine or a feminine fashion.

In considering the origins of these differences, let us examine recent information on neural and hormonal factors that appear to explain some sex differences in reproductive behaviour in rodents (especially rats) and in song birds (represented by the zebra finch and the canary). In both of these groups, courtship or copulatory behaviours differ between the sexes. Research on rodents originally served to define the important theoretical issues regarding the origins of sex differences in behaviour, yet recent work on song birds has demonstrated that rather large and pervasive anatomical sex differences in the brain may lie behind the behavioural differences.

In rodents, the act of mating usually involves little courtship, which may be related to the fact that pair bonds are not common. The male rat approaches the estrus female, mounts her from behind, palpates her flanks, and begins pelvic thrusting which results in several intromissions and then ejaculation. There ensues a period of little or no mounting, during which the male grooms himself before another copulatory sequence begins. The female behaviours are qualitatively different. When the female is in estrus and is mounted, she extends her hind legs, elevates her rump, and dorsiflexes her vertebral column, all of which constitute the posture of lordosis. Female rats will also show behaviours of darting and ear wiggling when pursued by the male. The sexual behaviours of rats are under the influence of sex steroid hormones; removal of the gonads eliminates or reduces the frequency of these behaviours while administration of gonadal steroids reinstates them. Thus, androgens reinstate male-typical behaviours such as intromission and ejaculatory thrusting, and estrogens (usually with progesterone) restore lordosis and other female-typical behaviours.

This sex difference in behaviour could reflect different behavioural capacities, or alternatively, it is possible that both sexes are capable of showing male- and female-typical behaviours, but that testicular hormones induce male-typical behaviours and ovarian secretions bring about female-typical behaviours. Indeed, castrated male rats given estradiol and progesterone will show some lordosis, and ovariectomised female rats given androgens will show some male-typical behaviours. Thus each sex possesses



PAINTING BY NANA SHIVALKAR

the capacity to show heterotypical behaviours, and hence must possess to some extent the neural circuitry responsible for heterotypical behaviours. However, it is also true that males given androgens will show more male-typical behaviours than females, and conversely, females given estrogen and progesterone display more lordosis and female-typical behaviours than males. Thus it is still possible that there are some real sex differences in neural networks which underlie these different reproductive behaviours. In this sense there may be real sex differences in behavioural capacities.

The organisational hypothesis

One of the most significant concepts in this area in the past few decades has arisen from the demonstration that the neonatal secretions of the gonads are important in determining whether an animal will behave in a male-typical or female-typical fashion as an adult. Genetic females injected with a single dose of androgen around the time of birth can be permanently masculinised behaviourally, as well as defeminised. That is, such a genetic female will show male-typical behaviours more frequently and female-typical behaviours less frequently as an adult, compared with a normal female. Similarly, males deprived of androgens by castration at birth will be feminised and demasculinised. (Perinatal ovarian secretions do not appear to play a role.)

This observation has spawned the notion that neural circuits underlying sexual behaviours are permanently "organised" by hormones during the neonatal period. Neonatal androgens are thought to enhance the formation or retention of neural pathways involved in male sexual behaviour, and to inhibit the formation or retention of neural pathways involved in female sexual behaviour. Actually the presence and absence of these two modes of behaviour are somewhat independent, since by manipulating the timing or nature of neonatal steroid treatment, it is possible to produce animals which show both male- and female-typical behaviours in adulthood. The two types of neural pathways are therefore not mutually exclusive.

Several authors have criticised the concept of organisational effects of hormones. One criticism is that with regard to male-typical behaviours in some species, such as the rat, it is possible to account for the "organisational" effects by assuming that the androgens masculinise the penis, increasing its size and tactile sensitivity, which in turn alters the propensity to show the male intromission and ejaculatory pattern. Indeed, in a number of studies in which steroid levels were manipulated neonatally, males showing the most frequent male sexual behaviour also had the largest and most heavily cornified penis. In similar studies, females showing the greatest behavioural masculinisation (that is, displaying the male pattern most frequently) had the greatest hypertrophy of the clitoris, so that it was nearly indistinguishable from a penis. The strength of this argument for peripheral rather than central masculinisation is diminished by the finding that a synthetic androgen given neonatally can masculinise the penis without increasing the display of some male-typical behaviours, and by the discovery that implants of steroids in certain areas of the brain during the neonatal period can masculinise or defeminise rats.

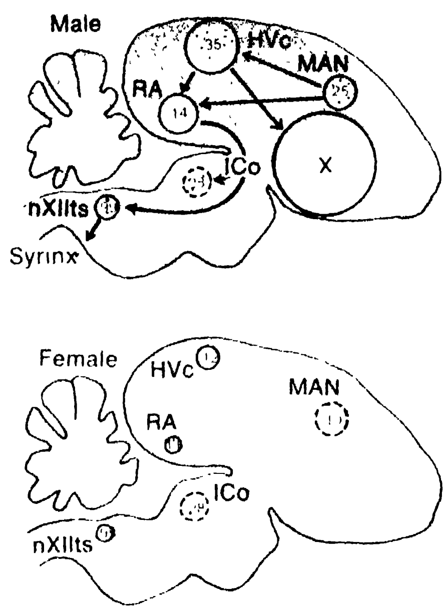


Fig 1 This highly schematic drawing shows several of the brain regions believed to be involved in the control of song in passerine birds Circles represent individual brain areas, some of the anatomical projections of these regions are indicated by arrows The size of each solid circle is approximately proportional to the volume occupied by that brain region in the zebra finch Circles with dotted lines indicate brain regions whose volumes have not been estimated (i e female MAN and ICO in both sexes) Dots mark regions which contain cells labelled by radioactive testosterone injections in zebra finches, the numbers within the circles indicate the approximate percentage of cells labelled Sex differences in volumes of HVC, RA, and XIIts are illustrated, as well as the fact that Area X cannot be seen in Nissl-stained sections in female zebra finches The figure also shows the sex difference in percentage of steroid-labelled cells in HVC and MAN In other brain regions, sex differences in steroid labelling are not statistically significant

It should be noted that the arguments against the organisational hypothesis have been indirect, showing that some of the effects of early androgenisation could be accounted for by processes which do not involve organisation of the central nervous system. However, it would be possible to prove the hypothesis directly by demonstrating sex differences in neural organisation. To do this, it is important to decide precisely what types of differences in structure or function constitute "organisation".

For the present purposes, let us define an organisational difference as a quantitative or qualitative difference in the synaptic contacts made among neuronal populations involved in a behaviour. To give the organisational hypothesis strong support it would be necessary (1) to find a morphological or physiological sex difference which was (2) of an organisational nature or implied an organisational difference, (3) in a neural circuit known to be involved in a sexually dimorphic behaviour, and (4) capable of manipulation by the same neonatal steroid treatments known to determine the direction of sexual differentiation of behaviour. In recent years, all but one of these pieces of evidence have been obtained for mating behaviour in rats, and all four have been demonstrated in the neural system controlling song in passerine birds.

Proving the hypothesis

The suggestions of anatomical differences between the sexes came with reports that in rats, there is a sex difference in the size of nuclei in neurons in the preoptic area, the anterior and ventromedial hypothalamus, and amygdala; that neonatal castration of males feminises the brain by this measure; and that this feminisation can be blocked by neonatal androgen injections. However, such differences in the size of cell nuclei do not necessarily imply organisational differences as defined here, although they may be related to such differences. The reported dimorphisms could have resulted from differences in circulating steroid levels in adulthood, since the measures were made in gonadally intact animals.

In 1971, researchers provided the first significant anatomical evidence for an organisational sex difference in the brain. They found a sexual dimorphism in the number of synapses on dendritic spines stemming from non-amygdaloid afferents in the preoptic area of the rat. This difference was reversed by neonatal androgenisation of females or neonatal castration of males. A second dimorphism, in the dorsomedial preoptic area, has been reported by other workers who have detected sex difference in the topographical distribution of Golgi-stained dendrites in the hamster which can also be manipulated appropriately by neonatal steroid treatments.

Recently, scientists have found an especially striking and easily measured anatomical dimorphism in the preoptic area of the rat. A medial preoptic nucleus, for which they have proposed the term "sexually dimorphic nucleus" (SDN) is approximately eight times larger in volume in castrated male rats than in ovariectomised females, when measured in Nissl-stained sections. The volume of this nucleus is larger in neonatally androgenised females relative to control females (both groups ovariectomised in adulthood), and is smaller in neonatally castrated males than in males castrated after the critical neonatal period for sexual differentiation. If it is tentatively assumed that the staining technique used to identify this nucleus in fact serves to define the anatomical limits of a functional population of neurons, then the difference in volume implies an organisational difference. The reason for this is that a difference of this magnitude is likely to entail a difference in the number of neurons in the population and/or in the volume of dendrites and their afferents.

Although these studies prove the organisational hypothesis, thus far they fall short of verifying it with regard to behaviour.

Sexual dimorphisms in birds

We turn now to consider the vocal behaviour of the zebra finch. The evidence on bird song complements the much more extensive literature on rats, since for this behaviour some information exists on points that are unclear for rat behaviour, whereas information is scanty on other aspects which have been well studied in rats. In zebra finches, natives of Australia, males and females form long-term pair bonds that last more than one reproductive season. Males sing a short, rather quiet courtship song, accompanying it with other stereoty-

Where does the difference lie?

MEN AND WOMEN have been known to think and respond differently to situations as long as human society has existed. Is this because of some blueprints in the brain that we are born with?

For a long time, the interpretation of data derived from clinical studies of sex differences was viewed in terms of whether or not it confirmed male superiority. "During the period that women were thought to be more variable," writes Katherine Greene, the biographer of pioneering psychologist Leta Hollingworth, "women were considered inferior because they were more variable. When ... it seem[ed] true that men were more variable, then women were considered inferior because they did not vary as much."

Since the advent of the new women's movement in the West, the question of biological substrata of human behaviour has been raised afresh. Though they acknowledge that sex differences reflect social upbringing and environment, some researchers now are of the view that there may also be a neurological basis for these.

Though there are no observed dif- [illegible] in the brain size, structure and [illegible]ents of the sexes, a [illegible] tests suggest that men's and [illegible] d differently w[illegible] certain functions. These processes are controlled in different locations within the brain and they work in different ways.

Working in the early 1960s with patients who had a part of their temporal lobes removed in order to ease their epileptic seizures, psychologist Herbert Lansdell at the National Institutes of Health, USA came to the conclusion that the sexes might differ in brain organ[illegible] [illegible] woman's verbal and spatial skills are more likely to be duplicated on both sides of the brain, whereas a man, if right-handed, is likely to have each of his brain hemispheres specialising in one ability—verbal abilities located in the left and spatial abilities in the right.

Sandra Witelson's studies with normal groups showed further evidence towards this hemisphere specialisation of the male sex. This phenomenon is also known as brain lateralisation. However, the correlation between the degree of hemisphere specialisation and competence at a task is a complex question. Witelson suggests that "...men are superior on tests of spatial skills and tend to greater lateralisation of spatial function to the right hemisphere. Here greater lateralisation seems to be correlated with greater ability. However, in the case of language, women, in general, may be superior to men, who show greater lateralisation of language skills to the left hemisphere. Thus, with language, greater lateralisation may be correlated with less ability."

Under a variety of experimental situations, these sex differences seem to become more pronounced as a child matures. Working with children of five and eight at the University of Massachusetts, USA, Marylou Reid found that right-handed boys develop their right, hemisphere-located spatial skills more quickly than those located in their left one. [illegible], right-handed girls develop their *left* hemisphere more rapidly than their right, and they were ahead of the boys, in their age group, when it came to verbal skills. Perhaps the children were r[illegible] for each set of skills according to sex, and social expectations led them to practise these to a greater extent leading to associated hemisphere development.

One more area of hemispheric sex specialisation located by Richard Davidson and co-workers at Ha[illegible] is [illegible] of arousal and [illegible] The patterns of activation indicated that women's brains became selectively more active than men's. That is, women seemed better cognitive specialists, whereas men were able to perform tasks that require two different cognitive approaches at the same time better."

Diane McGuiness and Karl Pribram of Stanford University speculate that male and female hormones act to produce varied behaviour in the sexes, and, this in turn, leads to the development of certain areas of the brain.

But sociological evidence shows that sex differences in ability vary very much with culture. Women who live in societies where seclusion is enforced upon them have very poor visual-spatial skills compared to men, whereas in other societies where close co-ordination of skills of all members is essential for survival, men and women have similar development of abilities. The validity of the use of verbal-spatial skills as indicators of universal male-female differentiation can also be questioned.

Admirable as this kind of research effort may be, how does it add to our understanding of our human selves? Do we go on to further the development of one set of abilities in each sex, cutting off its potential in other areas in the name of efficiency? It may be feared that such preoccupations may, in fact, deflect attention from the real problems of women. By providing convenient slots within which to shelve the sexes, popular interpretations may lead to the pertuation of sexual inequality. "The real nger in this line of research", says rcel Kinsbourne, a Toronto neurologist, "is that the findings could be misinterpreted and used as a scientific justification of sexism, just as ambiguous genetic findings were often cited to provide a scientific basis for racism."

FEROZE CHANDRA

Feroze Chandra is on the editorial staff of [illegible]Y.

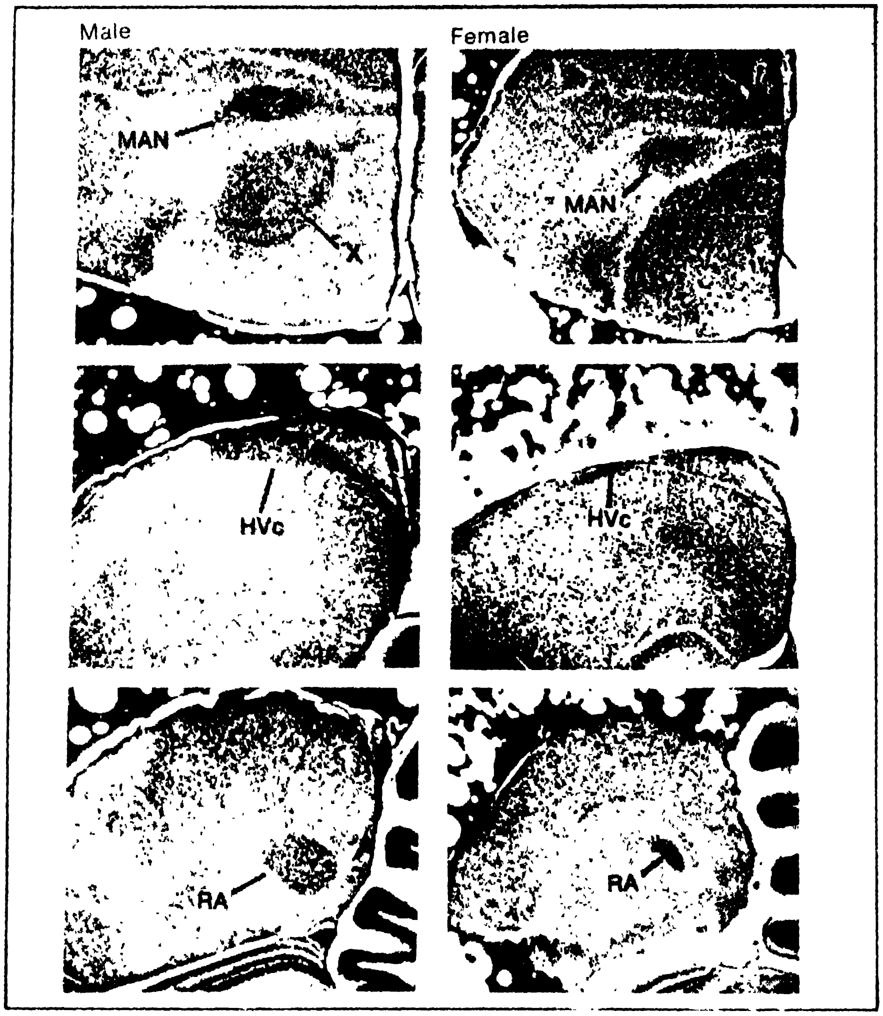
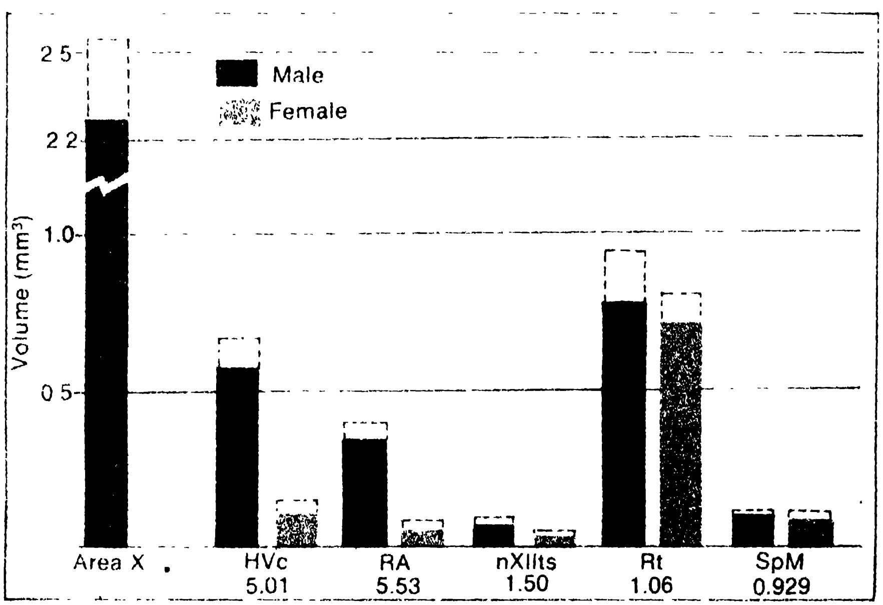


Fig 2 Photomicrographs allow comparison of several brain regions in male and female zebra finches In the uppermost set of photomicrographs, MAN and Area X are clearly seen in the male, the boundaries of MAN are much more diffuse in females, since the MAN cells are smaller Area X cannot be seen in females The middle set of photomicrographs shows the brain area designated HVc and the bottom set, RA The magnification is identical in each case

Fig 3 The graph shows the mean and standard deviation of volumes of male and female brain regions in the zebra finch, as measured in Nissl-stained sections Four brain regions thought to be involved in song (Area X HVc RA, and nXIIts) are compared with two non song regions the nucleus rotundus (Rt) and the nucleus spiriformis medialis (SpM) The ratio of male to female volume is indicated under each histogram pair In HVc, RA, and nXIIts the sex difference is statistically significant, whereas in Rt and SpM it is not



ped behaviours (feather erection, specific patterns of body orientation toward the female, tail deflection) which precede mounting and copulation. The male learns the song pattern from his father early in life, and the song is thought to function both as a courtship stimulus attractive to the female and as a signal communicating the individual's identity. Castrated males sing, court, and copulate less often than intact males, and androgen therapy reinstates song and other sexual behaviours. Females do not sing, even when given implants or injections of androgens.

There is a very clear sexual difference in the volumes of a number of brain regions thought to be involved in the control of song in the zebra finch and canary. There are two anatomically discrete telencephalic regions (the caudal nucleus of the hyperstriatum ventrale, or HVc, and the robust nucleus of the archistriatum, or RA) which are known to be involved in song control because lesions in these areas produce deficits in singing. These regions are connected with each other (Fig. 1) and with a number of other brain regions: the magnocellular nucleus of the anterior neostriatum (MAN) Area X of the lobus parolfactorius; the nucleus intercollicularis (ICo), and the tracheosyringeal portion of the hypoglossal motor nucleus (nXIIts). Significantly, this system sends a massive projection to the hypoglossal motor neurons, which innervate the muscles of the syrinx, the vocal organ The anatomical projections within this system first described for the canary are similar to those found in the zebra finch. Each new anatomical study of these brain regions has inevitably uncovered pathways to or from other brain regions, and thus our knowledge of the anatomy of this system is currently in a dynamic state

Sex differences in the anatomy of the brain regions involved in the control of song are both large and pervasive. In the zebra finch, the volumes occupied by HVc, RA, and nXIIts are considerably larger in males than in females, and in Nissl-stained brain sections Area X can be seen only in males (Figs. 2 and 3). Castration of adult males does not reduce the volumes of these brain regions, nor does prolonged androgen treatment of adult females increase the volume of HVc or RA. Androgen treatment of adult females does increase the volume of the hypoglossal motor nucleus somewhat, but not enough to erase the sex difference in the volume of this nucleus. Therefore, it appears that the sex difference in volume cannot be explained by sex differences in circulating androgen levels in adulthood. Interestingly, in canaries, circut [illegible] of androgens partially determine the volume of HVc and RA, since castration of males reduces the volumes of HVc and RA in males and androgen implants increase their volumes in females. However, volumes in androgen-implanted females are still smaller than those in castrated males, implying that another factor must be invoked to explain the sex difference.

A second measure of sexual dimorphism is cell size. In MAN, HVc, RA, and nXIIts, the size of cell bodies is significantly smaller in ovariectomised females as compared to castrated males shortly after both have received a single small injection of testosterone. The magnitude of this sex difference is not large enough to explain the sex dimorphism in the volumes of these brain regions. Rather, it would seem to be further indication of the widespread sex difference in the song system.

A third major sex difference in the song system involves differing levels of hormone accumulation by neurons in telencephalic brain regions. A surprisingly large number of song-control regions, including MAN, HVc, RA, ICo, and nXIIts, contain neurons which accumulate testosterone or its metabolites. Such accumulation is thought to be a prerequisite for many steroid effects on neurons and other cells. Since song is governed by androgens in adulthood, this accumulation suggests that androgens act at many levels in the brain to exert effects on singing behaviour. What is important here, however, is the sex difference in the number of steroid target cells; in males, a greater percentage of HVc and MAN cells are labelled in autoradiograms made after injection of tritiated testosterone. This difference in percentage of labelled cells (Figs. 4 and 5) undoubtedly reflects a large difference in the absolute number of steroid target cells in these brain regions. No overall sex difference in percentage of labelled cells has yet been found in the RA, but cells labelled in males are larger than those labelled in females.

Recent evidence from our laboratory indicates that these neural circuits have certain functional sex differences that can be revealed by the technique of microstimulation. It is possible to evoke electromyographic responses in the syringeal muscles by stimulation through a microelectrode placed in HVc or RA. Figure 6 illustrates typical results of two such experiments. In the first, a tungsten microelectrode insulated with glass was inserted into the right HVc of a male zebra finch after a light barbiturate anaesthetic had been administered. A short train of four microstimuli (0.3 msec pulses, 500 Hz, cathodal, monopolar) was delivered through this electrode, and at the same time electromyographic responses were recorded in the syringeal muscles which are involved in vocal control. The threshold for eliciting a response from the ipsilateral muscles was typically very low, under 5 microamperes, indicating that only a very small area of tissue needs to be activated in order to cause a syringeal contraction. This implies a rather strong indirect projection from HVc to the ipsilateral syringeal muscles. Similar results were obtained for the left HVc.

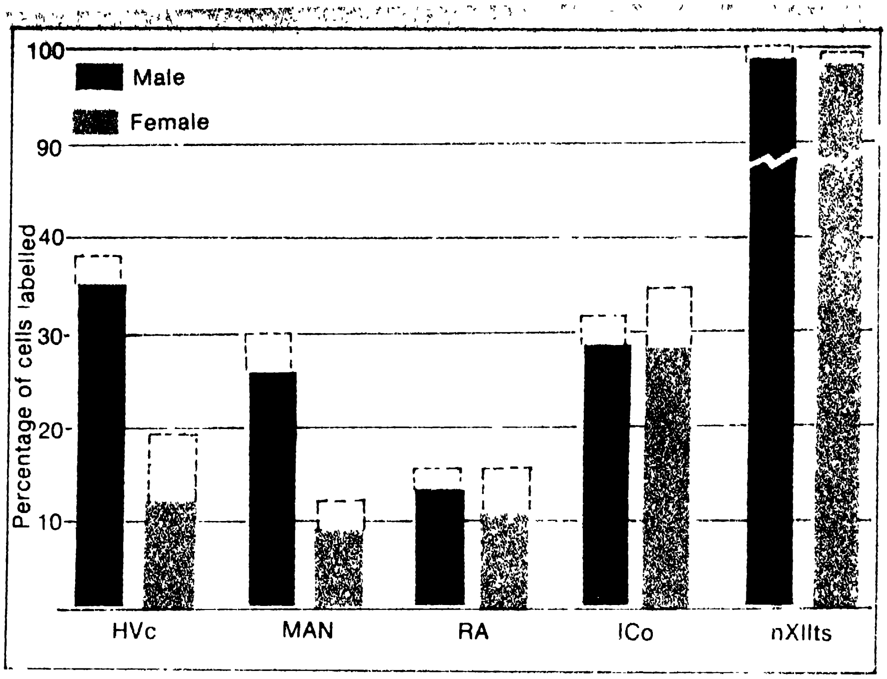


Fig 4 Histograms compare mean (+ standard deviation) percentages of cells labelled in five brain regions of male and female zebra finches after injection of tritiated testosterone into gonadectomised adults

The same technique was applied to a female zebra finch (Fig. 6), with a view to answering three questions. First of all, is HVc "hooked up" in the female, despite its small size? In other words, do neurons in the female HVc have the same or similar projections, making it possible to elicit syringeal contractions by stimulation in the female as well as the male? The results shown in Figure 6 indicate that stimulation of the female HVc does indeed produce such contractions. A second question was, can this method confirm that the female anatomical structure seen in the same location as the male HVc is, in fact, an HVc? The results suggest that this is the case, since syringeal contractions were elicited only when the electrode was situated in the anatomical structure illustrated in Figure 2, which is the female homologue of the much larger and different-looking male HVc. A third question was, is it possible to identify any sex difference in responses to stimulation of HVc? Typically, the male and female differed by at least two measures. Longer pulse trains were needed to produce a response in females, and the minimum threshold was usually higher in females than in males.

It is possible that this sex difference in threshold is related to the topographical proximity of the electrode to HVc. That is, the sex difference here could result from the fact that it may be difficult to stimulate a sufficient volume of tissue in the thin, flat HVc of females, as opposed to the thicker HVc nucleus in males. Thus, the sex difference in threshold may not reflect a functional difference in HVc neurons *per se*. When threshold is considered in relation to the number of pulses required for response, a clearer functional sex difference is seen (Fig. 7). More pulses are consistently needed to elicit a response at minimal threshold in females than in males, implying that more spatial or temporal summation is required in this pathway in females than in males. Therefore, the physiological experiments confirm that although HVc is operative to some extent in the females, it is possible to detect a sex difference in function which correlates with the extreme anatomical dimorphism.

It is important to emphasise that

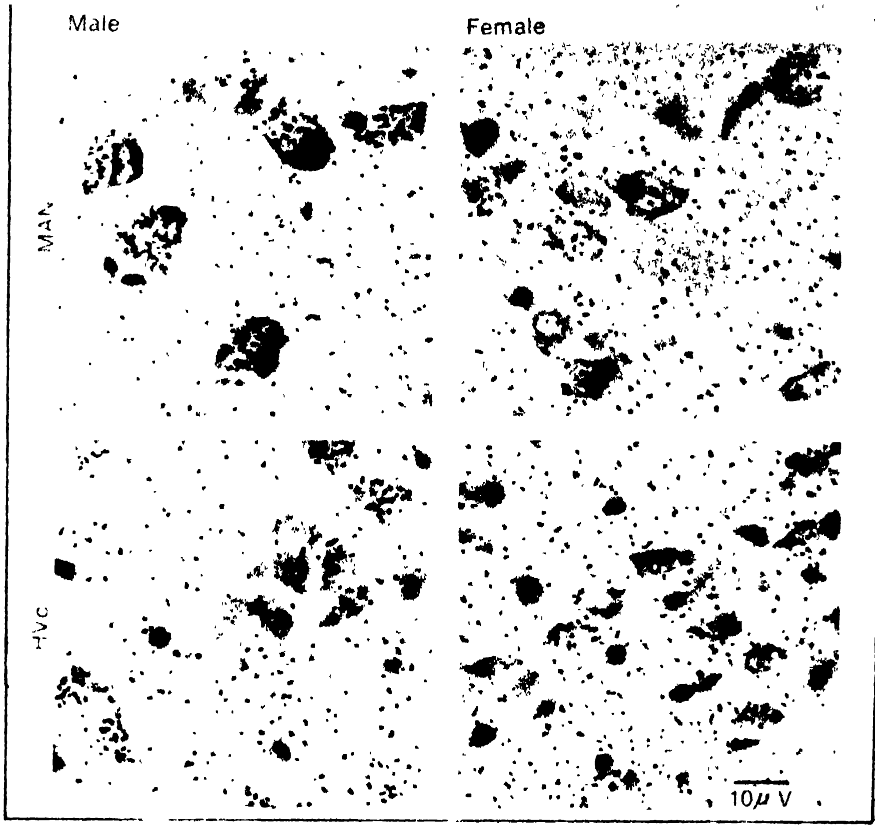


Fig 5 Two pairs of photomicrographs illustrate the sex difference in steroid accumulation as seen in thionin-stained autoradiograms of MAN (above) and HVc (below) in male and female zebra finches after injections of tritiated testosterone

the studies reviewed here have identified an interconnected group of neuronal nuclei which are thought to control a sexually dimorphic behaviour, and that for the brain regions shown in Figure 1 there is a sex difference in most anatomical features measured thus far, as well as in some electrophysiological characteristics. This is the reason that the sex difference found in the zebra finch brain was earlier described as pervasive. In fact, this sex difference is not limited to the neural system controlling song. The syrinx itself has a much larger muscle mass in the male zebra finch than in the female, which confirms earlier reports of sex differences in the syringes of other passerine and non-passerine birds. It is only a slight overstatement to say that the process of sexual differentiation has left no stone unturned in reducing the female's ability to sing.

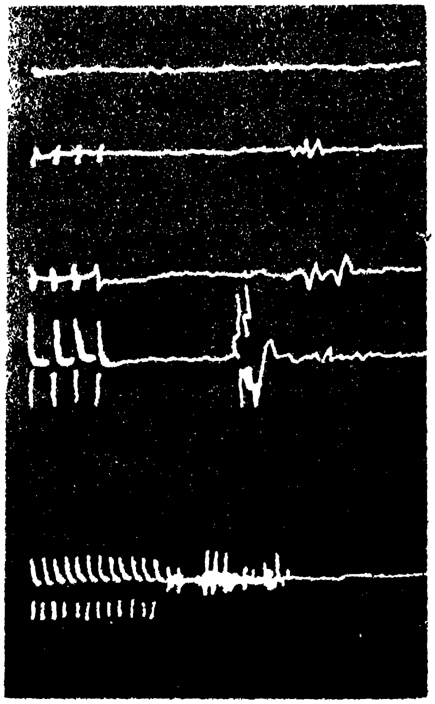
Recently researchers have discovered that steroid manipulations in neonatal zebra finches profoundly affect the singing behaviour and the structure of the brain in adulthood. If female zebra finches are given estradiol on the first day of life, the structures of HVc, RA, MAN, and Area X are masculinised, although the volumes of HVc and RA are intermediate between those of normal males and females. The androgen dihydrotestosterone is not effective in producing these changes. Females given estradiol neonatally do not sing as adults unless they are given androgens in adulthood. The adult androgen treatment appears to complete the sex reversal of the neural network controlling song, since HVc, RA, the dorsomedial portion of ICo, and nXIIts achieve volumes comparable to those found in normal males. Since androgen treatment of normal adult females has no apparent effect of the volumes of HVc and RA, neonatal estradiol treatment appears to render HVc and RA sensitive to the trophic effects of androgen in adulthood. These exciting results indicate that behavioural masculinisation of females is correlated with masculinisation of neural regions controlling song, and that, as in rodents, neonatal steroids are crucial determinants in the process of sexual differentiation. The work will no doubt lead to other studies which will clarify why estradiol is effective in masculinising females, while androgen is not, and identify the cellular mechanisms by which estradiol exerts this action.

Complementary evidence

To demonstrate how the evidence for rats and song birds is complementary, it is informative to compare our current knowledge on these two groups with regard to the organisational hypothesis and related issues. This is perhaps best accomplished by posing a number of interconnected questions and answering them from both literatures.

First of all, is it possible to find sex differences in brain organisation? For both groups we know of significant morphological dimorphisms which imply that the brains of males and females are organised differently. What sexually dimorphic functions are performed by these dimorphic brain regions? In the case of rats, the dimorphisms have usually been found in the preoptic area, which is known to be involved in more than one sexually dimorphic function; it is therefore unclear at present whether the dimorphisms are related to reproductive behaviour or to some other

Fig 6 Microstimulation of the right HVc of a male zebra finch (above) produced these electromyographic recordings of muscle contractions in the left (L) and right (R) ventral intrinsic syringeal muscles. In the top pair of traces, a train of four pulses (1 2 microamperes in amplitude) was delivered, and a small response was recorded on the right side. When the current was increased to 10 microamperes, a larger response was seen on the right side, and a small response was also evoked on the left Below, similar responses were elicited in a female by a train of 12 pulses (26 microamperes) delivered to the left HVc



function. It might be claimed that the functional importance of the dimorphic nuclei is more easily understood in song birds, where such nuclei appear to be related to song. Indeed, the ability of the female to sing is correlated with the size of these brain regions. But some caution must be exercised, since our knowledge of the functional importance of various portions of the song system is very slim, and it is possible that the neurons in at least some parts of the so-called song system might be involved to some extent in other sexually dimorphic behaviours or neuroendocrine functions.

Can the neural and behavioural dimorphisms be manipulated by the same neonatal steroid treatments? For both rats and song birds, it is possible to manipulate the neonatal steroid milieu to produce a genetic female whose brain appears male-like, and whose behaviour is also masculinised. Neonatal steroid treatments have also produced genetic male rats whose brains appear female-like, but this has so far not been accomplished in song birds.

At what functional levels in the neural circuits controlling behaviour are there sexual differences? In other words, does the differentiation process modify sensory pathways, motor effectors, neural pattern generators, general arousal mechanisms, or other systems? It is difficult even to begin to answer this intriguing question for either the rat or the song bird. However, considering the pervasive dimorphism observed in the song system, it is possible to conclude tentatively that in this case the process of sexual differentiation produces changes at *many* levels, including the motor effector (the syrinx), all of which result in a reduction in the functional capacity of the system in females.

This multilevel, pervasive effect may well exist in rats also, since dimorphisms have been found in at least two different regions of the rat preoptic area and in a pathway from the amygdala to the preoptic area. In addition, in cats there is a sex difference in the number of preganglionic sympathetic neurons in the spinal cord, and in rats, variations in the morphology of the penis have been correlated with the propensity to show intromissions and ejaculatory thrusts. Such variations in penile morphology could be related to sex differences in sensory or motor structures. Indeed, we have recently found that the motor neurons innervating straited penile muscles in the rat form a distinct nucleus in the lumbar spinal cord, and that this nucleus is absent in females.

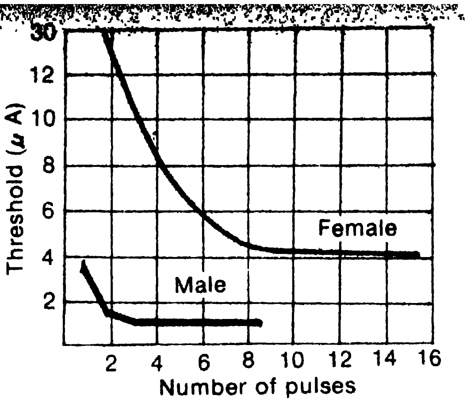


Fig 7 Typical curves for males and females show the threshold currents needed to evoke electromyographic responses in ipsilateral syringeal muscles by stimulation of HVc, plotted as a function of the number of pulses delivered More pulses were needed in females, and the threshold was consistently higher

Practical implications

The discovery of sexually dimorphic neural populations is of considerable practical interest because it opens up a number of lines of research aimed at elucidating the mechanisms of sexual differentiation of the brain. It is important to study the cells making up these populations from the time of their birth to maturity; before, during, and after the critical period or periods for sexual differentiation; both *in vivo* and *in vitro*; and under both normal and experimentally altered conditions. Such studies have now become feasible in both rats and song birds, and are quite likely to reveal the sites at which, and mechanisms by which, sex differences in neural function are produced.

It is essential to describe these neural populations as fully as possible so that we can recognise them from the earliest stages of development and identify precisely which aspects of the populations are dimorphic. In addition to the initial anatomical and physiological studies outlined here, we have now begun histochemical investigations of some of the brain regions involved in song control.

In one study in our laboratory, nerve fibres and terminals in Area X and the surrounding lobus parolfactorius (LPO) were found to contain catecholamines, a class of compounds also thought to be neurotransmitters. In material prepared with a glyoxylic acid technique, Area X can be seen to fluoresce more brightly than the surrounding LPO in males, whereas Area X cannot be seen in females by means of this technique. The catecholamine-containing fibres appear to project from the fluorescent cell bodies in the area ventralis of Tsai (AVT), since lesion of AVT eliminates or vastly reduces the fluorescence in Area X and the adjacent LPO. Because Area X fluoresces more brightly than nearby LPO in males but not in females, it is likely that the neurons projecting from AVT to Area X are sexually dimorphic in some characteristics, such as extent of axonal branching, number of terminals, or content of catecholamines.

These observations indicate that there are sexual differences in topographical distributions of the enzyme acetylcholinesterase (AChE) and catecholamines in Area X and in its homologous region in the female. Such findings are the first step toward using histochemical and biochemical measures of cholinergic and catecholaminergic function to study the normal development of this area, and to explore how certain experimental interventions disturb this normal development. They also open the door to pharmacological manipulations of this brain region which will allow us to study how disruptions of specific chemical transmitter systems affect the functioning of the song system in adults, and how such chemical modifications change the process of sexual differentiation during development.

The organisational hypothesis, first set forth clearly some two decades ago with regard to behaviour, has been given strong support in the last ten years by morphological and physiological studies of the brain. The question in this field of study is no longer whether or not sex differences in neural organisation exist, but rather what sequence of developmental events leads to the pervasive sex differences observed. Now that we know of specific, anatomically identified dimorphic neural populations, it is possible to focus our attention on these populations and to begin to find out how sex differences in neural development lead to sex differences in behaviour. These animal studies do not tell us, of course, whether there are anatomical sex differences in the human brain. However, they may provide some motivation for anatomists to search for such differences in the future.

Arthur P Arnold is Assistant Professor of Psychology and a member of the Brain Research Institute at the University of California, Los Angeles USA where his research centres on anatomical sex differences in the central nervous system, steroid effects on neurons, and neuroethology of bird song. He joined the faculty of UCLA in 1976, after receiving his Ph D.

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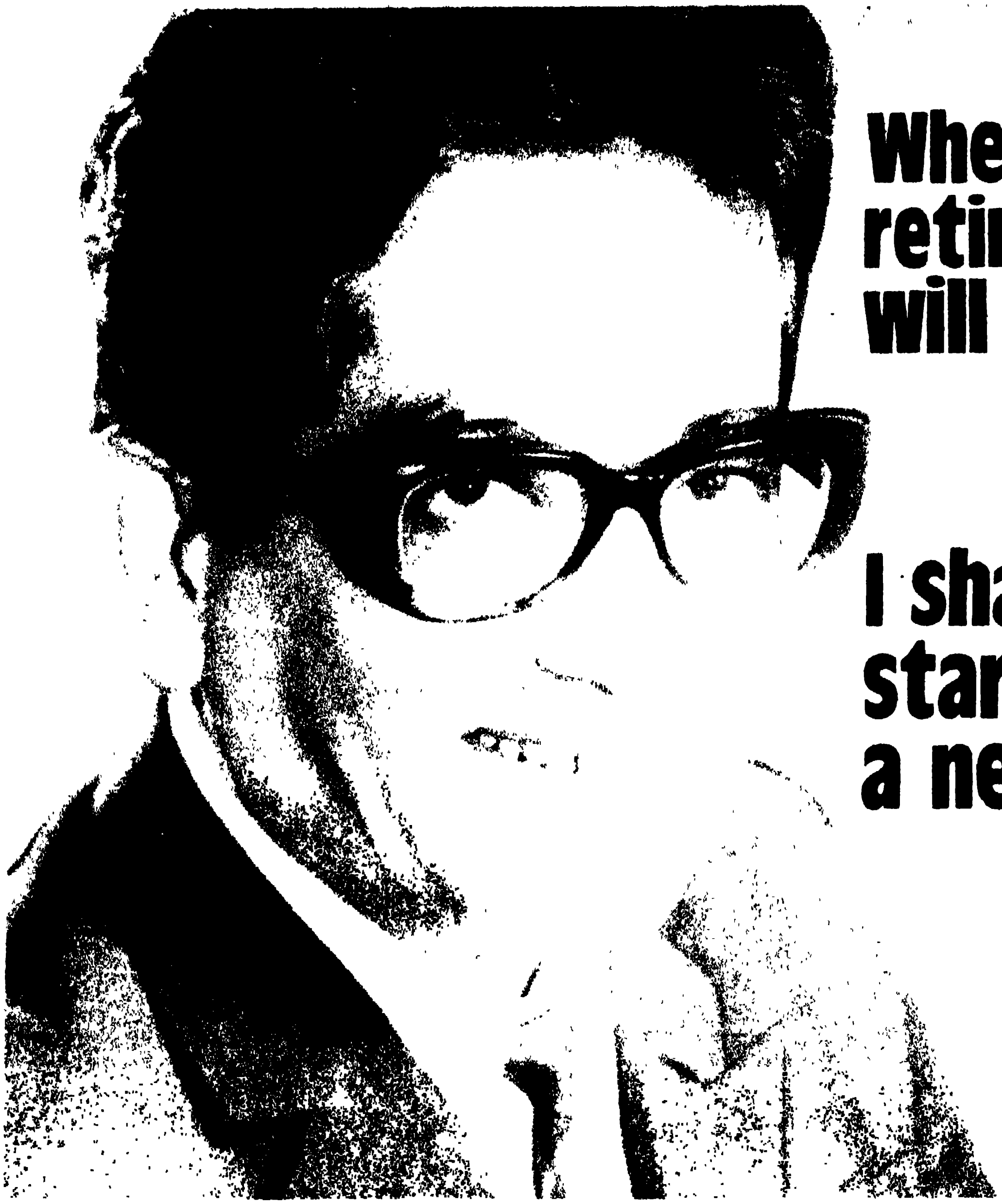

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...why are railway tracks dug up?

A LARGE number of labourers toiling in the sun, busy digging up sand and pebbles, tightening up nuts and re-packing stones on a railway track. Rakes, shovels, hammers and spanners are swung. Suddenly the train comes, and the men at work move aside. The train passes by, and the men get back to work, though the track is in perfect condition. A familiar sight wherever there are trains.

You must have wondered why railway tracks in good condition are periodically dug up for no apparent reason, especially before the monsoons. Well, this work happens to be very essential for the smooth running of trains, for keeping the track trim, smooth, efficient and accident-free

Today's trains are getting faster and faster, so fast that railways can sometimes—as in Japan—compete with airliners. So, if the engines and carriages do not move smoothly, it causes not only greater wear and tear of vehicle parts and tracks, but also travel will be bumpy and uncomfortable, and delicate and expensive cargo can get damaged.

The railway track is an elastic structure and its resistance has to be maintained if bad running and too much wear and tear are to be avoided. If track alignment is not perfect, there will be side thrusts on the lines which could cause derailment. Incorrect track levels, too, can result in a host of problems like swaying, bumping, and heavy wear and tear. Maintenance is even more difficult on curves.

One of the important aspects of this operation is the maintenance of 'ballast'. Ballast, in a railway track, is the broken-up stone or other material like slag, brick or sand provided underneath and around the sleepers.

The ballast serves a variety of functions. It provides a suitable foundation for the sleepers; it distributes load from the sleepers to the formation; it keeps the sleepers in their correct position, preventing any displacement, longitudinal or sideways; it provides an easy method for correcting levels and alignment; increases elasticity of the track and helps in drainage of water from the track.

The load which the track can support without being unduly depressed depends upon several factors. These include the strength of the rail, the type, size and spacing of sleepers, the stability of the formation as well as the quality, condition and depth of the ballast.

The figure shows a section of the track, giving the components of the track for the important track sizes, metre and broad gauges, used in India.

The best ballast is that which contains ones varying in size from 1.8 cm to 5 cm, with reasonable proportions of intermediate sizes. Each metre of a broad gauge track requires approximately 39.6 cu m of ballast. Metre gauge tracks require about 28 cu m. Slight variations in quantity may be called for, depending on the type of sleepers used. Wooden and concrete sleepers require slightly less ballast than pot or trough sleepers.

A properly maintained track drains off rain water and that is why the 'gangs' try to finish operations before the monsoons. It is essential that the water be drained because it helps lateral movement of the track.

Experiments have shown that the lateral strength of a track depends chiefly on the sleeper spacing and on the amount of grip the sleepers have on the ballast, either through friction or otherwise.

Now, what are the main problems faced in maintaining the ballast? In rainy weather, weeds grow on the formation (see figure) and on the ballast. This could obstruct drainage. Again, the constant hammering of wheel loads causes the ballast to get pulverised, and even the hardest pieces get reduced to dust in no time. The powdered material fills the interstices and voids in the ballast.

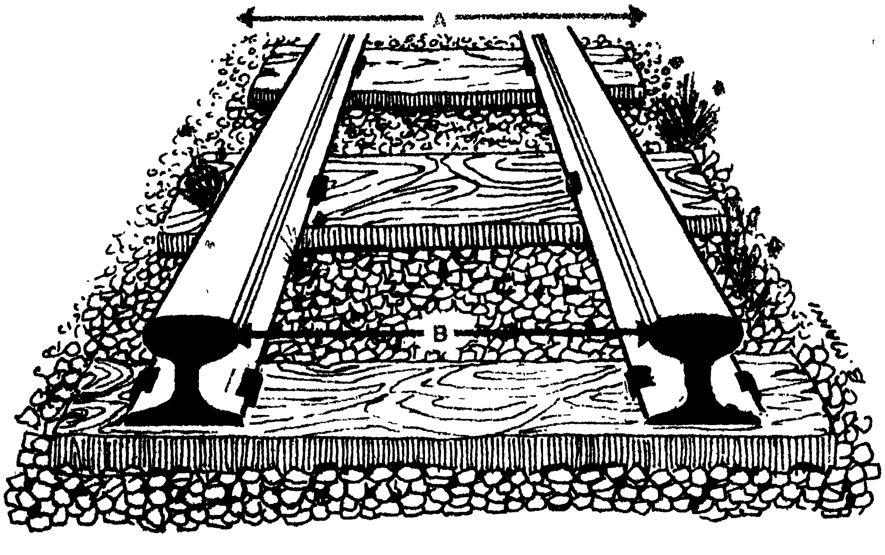
Ashes dropped from the locomotive, dust sucked up from formation, particles blown by wind, growth of vegetation and dirt otherwise gathered, all augment this process and the ballast layer gradually becomes impermeable. Drainage thus gets affected, with the ballast layer gradually getting filled. This reduces the resistance or springing action, very essential for smooth running of trains.

Railway 'gang' prepares ballast under broad gauge track

So that's what the workers are so busy doing with their rakes and pick-axes. They have periodically to replace the formation with clean stocks of new ballast. Ballast that may have spread about is neatly replaced and adjusted in the formation or stacked away in the sides for use later. This neat arranging of ballast is known as 'boxing'.

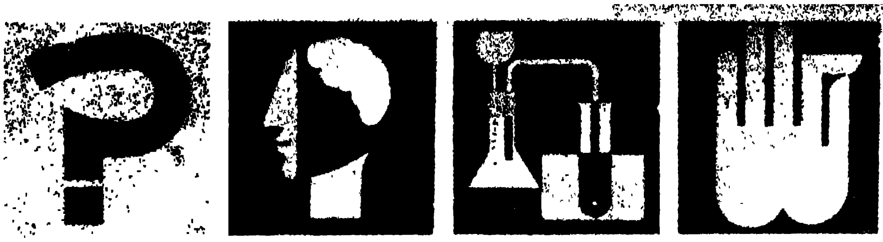
N.S. VASUDEVA RAO

Prof. Rao is with the Civil Engineering Department, Victoria Jubilee Technical Institute, Bombay.



	Formation width (A)	Formation depth	Gauge dist.(B)	Ballast depth below sleeper	Sleeper dimensions
Broad	335	33	167.6	20	274 x 25 x 13
	229	32	1000	15	183 x 20 x 11

Dimensions in cm of track components for broad and metre gauges



The method of science
6

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An important attribute of science is the right to question

Knowledge advances and science progresses because people exercise their right to question.

However, to question existing knowledge (for example, a fact or a law arrived at through the method of science) without any rational basis is as unscientific as never to question at all.

The reasons for your questioning may be:

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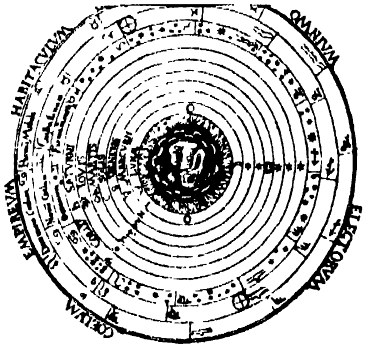
An example of the consequence of questioning

Five hundred years ago, it was universally believed that our earth was the centre of the universe and that the sun and the planets revolved around it.

COPERNICUS (1473-1543) questioned this belief. His questioning satisfied the criteria we have just stated. He used the method of science and his creative ability to show that his doubt was justified and that the age-old belief in an earth-centred universe was unfounded.

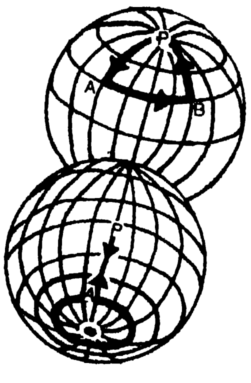


The Aristotelian cosmos

Another example

For centuries, it was believed—and many people still do—that there is only one point on the surface of the earth from where if you travel 1 km south, then 1 km east (or west), and finally 1 km north, you would reach the same point from where you started. This point, they believed, is obviously the north pole.

Not long ago, someone questioned this belief, and came out with the interesting finding that, in fact, there are an infinite number of points lying on a series of loci on the earth's surface, from where one could do the same thing!



Bottom. P→ A: South along a longitude.

From A eastward along a latitude back to A. The point A is so placed that the distance travelled eastwards along the circumference of the latitude equals one kilometre.

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STRUCTU

In the 19th century, JOHN DALTON, a British scientist, formulated his famous atomic theory. According to the theory, all elements consist of atoms which are indivisible. The atoms of an element are identical to each other in size and weight but differ from the atoms of all other elements in these respects, and atoms of elements combine in simple ratios to form compounds.

Current concepts of structure of matter explain all that was explained by Dalton's atomic theory

and

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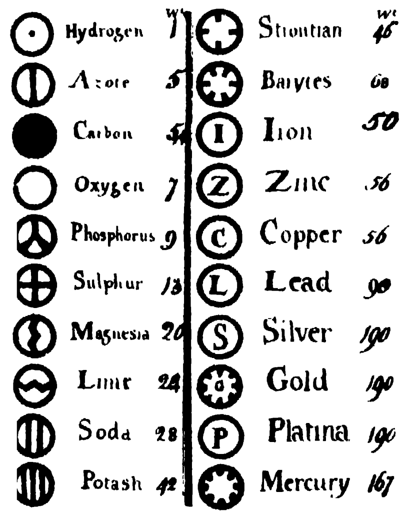
F MATTER


ELEMENTS
wt
Hydrogen 1
Azote 5
Carbon 54
Oxygen 7
Phosphorus 9
Sulphur 13
Magnesia 20
Lime 24
Soda 28
Potash 42
wt
Strontian 46
Barytes 68
Iron 50
Zinc 56
Copper 56
Lead 90
Silver 190
Gold 190
Platina 190
Mercury 167

The elements and their atomic weights according to Dalton

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Another example of progress in science

MOTION OF OBJECTS AND PROPERTIES OF LIGHT

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SPEED LIMIT
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RANJAN RJ.

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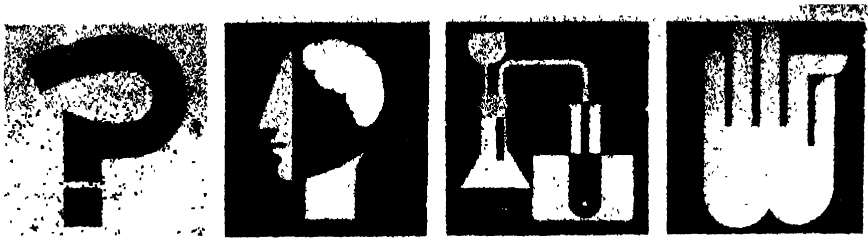

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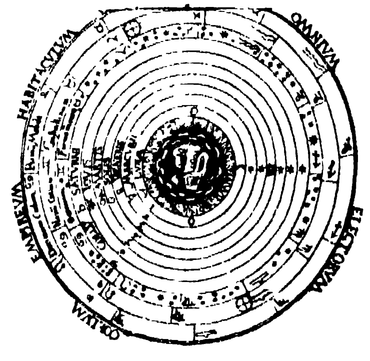

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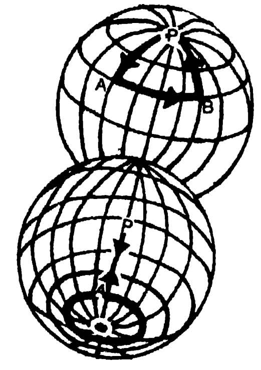

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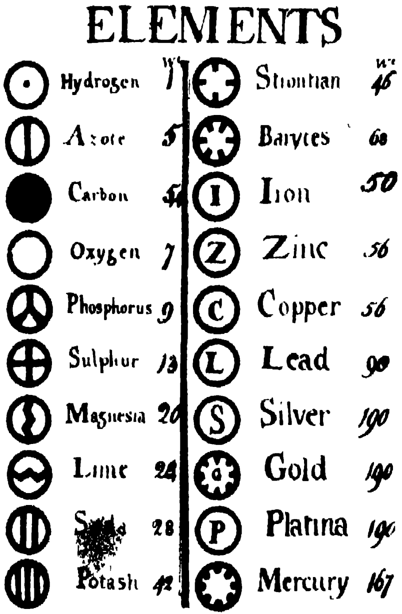

ELEMENTS

	Wt		Wt
Hydrogen	1	Strontian	46
Azote	5	Barytes	68
Carbon	54	Iron	50
Oxygen	7	Zinc	56
Phosphorus	9	Copper	56
Sulphur	13	Lead	90
Magnesia	20	Silver	190
Lime	24	Gold	190
S[illegible]a	28	Platina	190
Potash	42	Mercury	167

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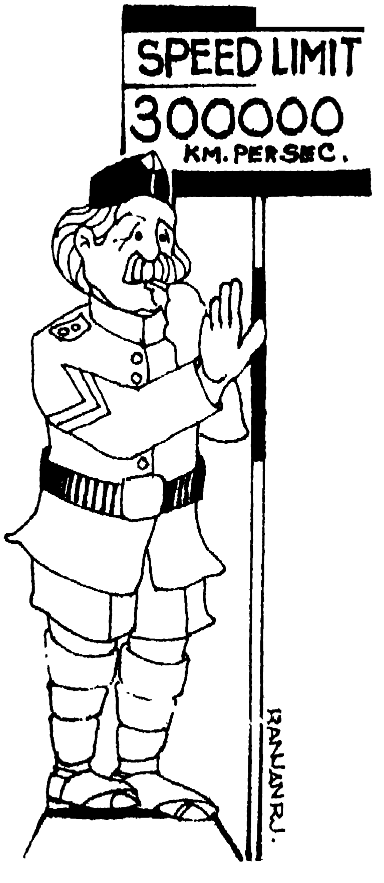
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Musical dancing lights

LIGHTS dancing in tune with music? If you wish to brighten up your music sessions with psychedelic effects you can do so simply by connecting two wires from the unit to the loudspeaker connections of your amplifier, tape recorder or radio. The lamps will start dancing in tune with the music being played.

The device basically is the improved version of "Dancing lights", published in SCIENCE TODAY, June 1973

The complete electronic circuit of the device, from the functional point of view, can be divided into four parts: the power supply, the lamp driving the two-transistor stage, the two-transistor Schmitt trigger and the sensitivity control stage.

The two end connections of the sensitivity control potentiometer should be connected across the loudspeaker terminals of the audio equipment. This will supply to the device electrical voltages which correspond to the music being played. This voltage, after rectification and filtering will be fed through a 3.3K resistor to the input of the Schmitt trigger stage.

When the music is not played, the input voltage fed to the first transistor Tr1 of the Schmitt trigger is zero. Thus the transistor remains cut off. As the input of transistor Tr2 is connected, through the 56K and 68K voltage divider, across the collector-emitter of Tr1, the transistor Tr2 remains in saturation. When the transistor Tr2 is saturated, its collector-emitter are effectively shorted together. As a result, the voltage "Ve" across the common emitter resistor of 330 ohms can be calculated by considering the voltage divider action which comes to 1.56 volts. Thus, it is clear that for any value of input voltage less than 1.56+0.6=2.16, the added 0.6V being the forward bias voltage required for the silicon transistor Tr1, there can be no base current through Tr1. The transistor Tr1 remains off and Tr2 remains saturated.

While playing the music, for a particular high amplitude musical note, the input voltage to the Schmitt trigger can go above 2.16V and the base current can flow through Tr1. Once this happens, its collector current increases and the voltage at its collector decreases. This drop in the voltage across the collector-emitter of Tr1 brings the transistor Tr2 out of saturation. The reduced collector current of Tr2 also reduces the common emitter voltage Ve. As 'Ve' gets reduced, Tr1 goes more into saturation. The regenerative process continues till Tr1 becomes fully saturated and Tr2 cut off. This changeover of the saturated states, from Tr2 to Tr1, because of difference in ohmic values of their collector resistors, reduces the common emitter voltage Ve from 1.56 to 1.09.

As the common emitter voltage Ve is reduced to 1.09 volts, the input voltage to transistor Tr1 has to be reduced less than 1.09+0.6=1.69 volts to bring the transistor out of saturation. When the input voltage is reduced below 1.69V, the collector voltage of Tr1 increases, causing Tr2 to conduct. With Tr2 coming into conduction, the common emitter voltage 'Ve' increases, causing the collector current of Tr1 to reduce further. This once again causes a regenerative action which continues till Tr1 is cut off and Tr2 is saturated. Thus, the circuit comes back to the original condition.

The value of input voltage which changes the saturated state from Tr2 to Tr1 is called the upper trigger point or UTP. Similarly, the value of input voltage which brings the circuit back to the original condition is called lower trigger point or LTP.

When the Schmitt trigger is in the triggered state, the transistor Tr1 in conduction, drives power transistor Tr4 through Tr3 into conduction. This switches on the lamps. The Schmitt trigger action compensates for the thermal inertia, that is, the time taken by the filament lamps to light after the application of voltage. This time duration of a fraction of a second though insignificant normally for lamps, is important in this dancing lights experiment.

When the unit is properly wired and

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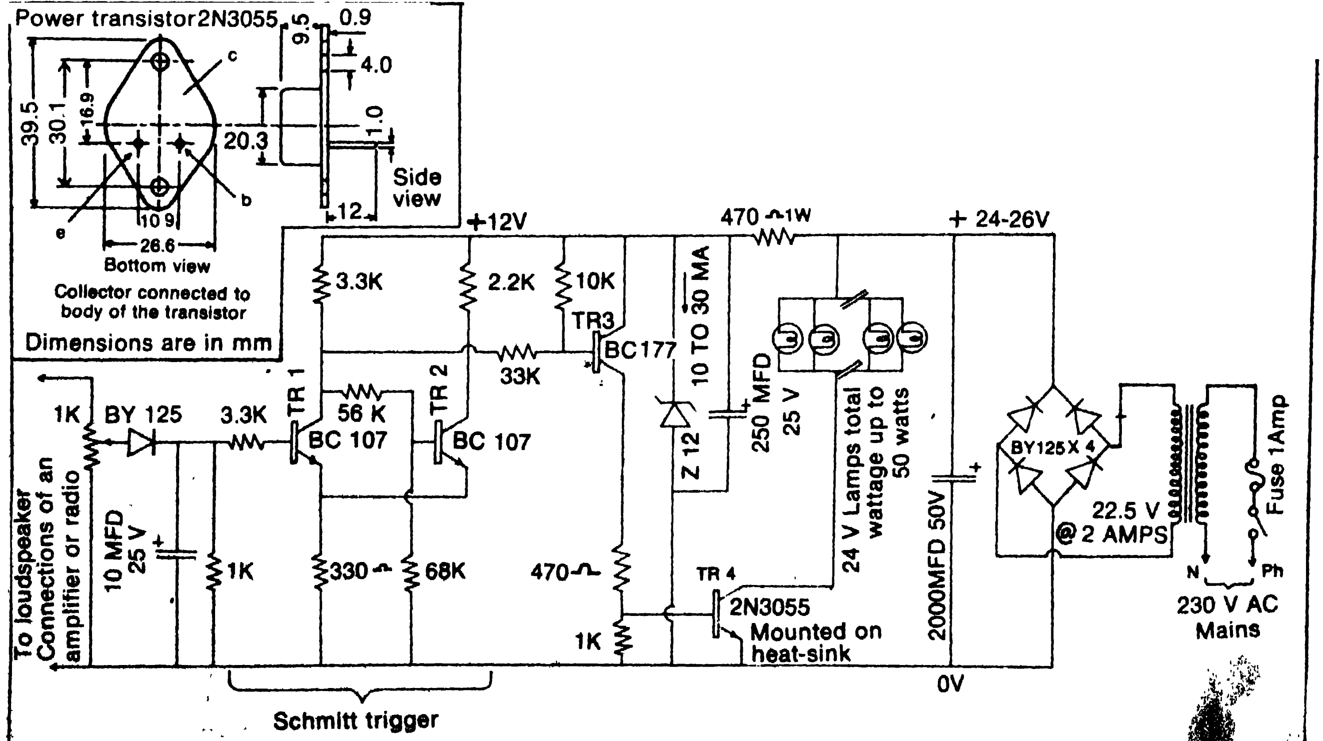


$$\text{UTP}=\underbrace{\frac{330}{2200+330}\times 12}_{\text{Ve}}+0.6=2.16\text{V} \qquad \text{LTP}=\underbrace{\frac{330}{3300+330}\times 12}_{\text{Ve}}+0.6=1.69\text{V}$$

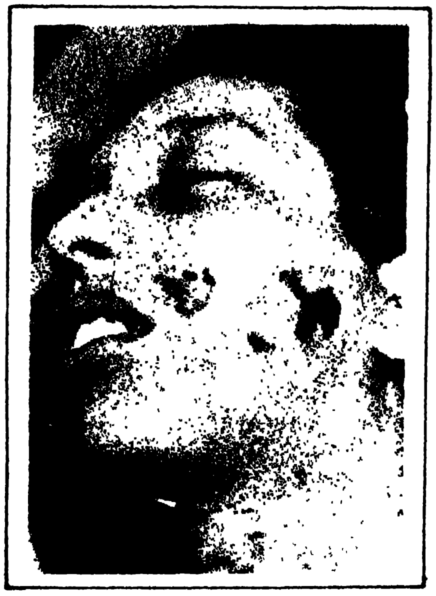
The Doctor as Detective

Spotting the criminal

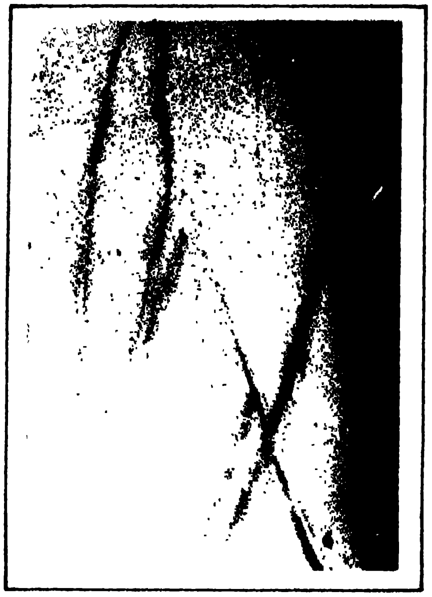
The sixth 'W' of the series deals with who the killer is

Pritam P. Phatnani

ONE often reads in murder mysteries about the murderer leaving a clue behind which points towards him directly or indirectly. Truth, however, is stranger than fiction: a woman was strangulated to death by her husband, who then absconded. He had also attempted to slit her neck. In this process he had bitten her on the cheek, leaving behind an impression of the teeth. Upon his subsequent arrest and examination a plasticine cast was made from his teeth. This matched perfectly in pattern and measurement with the pattern and measurement of each tooth whose impression was found on the cheek of the victim. Thus, he was identified as the killer.



Teeth marks on the cheek of victim, which tallied with the teeth of the accused



Serrated edges of the wound, which suggested that the lethal weapon was a kitchen knife

One might wonder how a doctor, from a postmortem examination of the body alone, can say anything about the criminal's identity. Examination of the scene of crime, as well as that of the suspect also plays an important role in the uncovering of the murderer. Careful examination of the body on the postmortem table, while disclosing the cause of death, also indicates what kind of weapon was responsible for the death. The weapon can often be connected directly with the assailant. (In the previous article we have seen how the postmortem examination gives a clue to the weapon.) The following case illustrates very well how this information can be utilised for detecting the criminal:

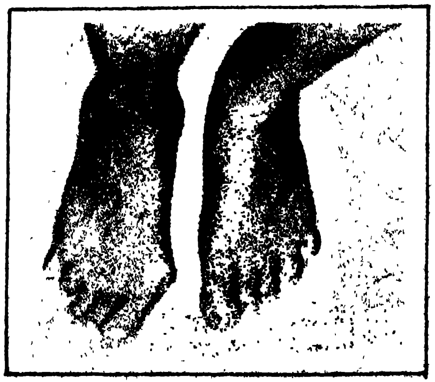
A murder took place in Juhu, Bombay, during a street-fight. A local bully was assaulted by eight armed persons at about 11 p m. The whole incident did not take more than a few minutes. The only witness to the scene was an old woman who disclosed that all the assailants were armed with lathis, except one who had a knife. She could not identify the individual assailants but they were all employees of a hotel nearby. They had quickly disappeared after setting upon the victim, leaving him dead.

The postmortem examination of the body next day revealed as many as 26 knife injuries, three of which were deep gashes and the rest all superficial cuts. The death was a result of the knife injuries. The superficial cuts became the vital clues to the solution of the crime, for the edges of these cuts had a zig-zag appearance like a carpenter's saw. This clearly indicated that the knife had serrated edges like those on a kitchen or bread knife. Now the question was, who, of all the hotel employees, had easy access to a kitchen knife? Obviously, the cook. Detailed investigations subsequently revealed that the cook of the hotel was one of the assailants and he did carry the kitchen knife with him during the assault.

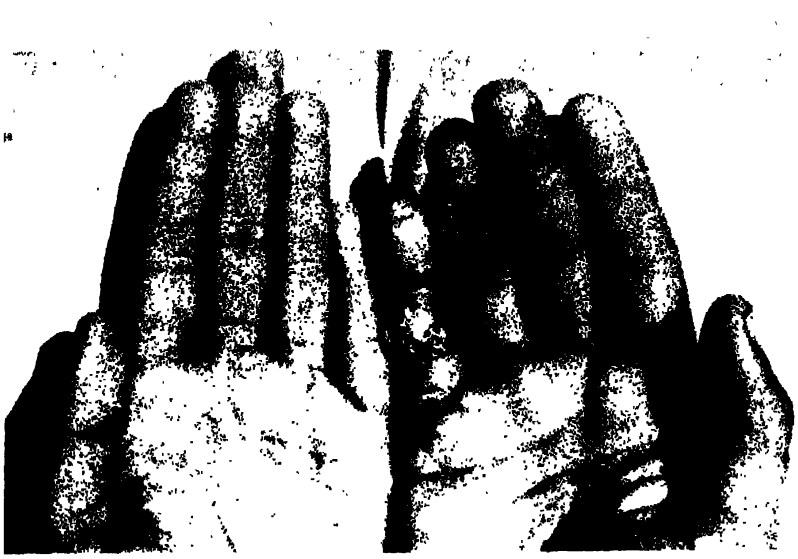
At times, the assailant himself is injured during the struggle—by a weapon or by the nails of the victim. When such nail marks are found on the suspect, clippings are taken from the nails of the victim. These are examined thoroughly by the chemical analyser following the postmortem examination. The blood and tissues of the assailant are often detected in these nail clippings, which on comparison with the blood sample collected from the assailant will implicate him conclusively. Often the assailant himself leaves his nail marks on the victim, specially in cases of manual strangulation. In such cases the nail clippings of the accused will reveal the blood and tissues of the deceased. Similarly, in cases of sexual assaults the assailant can be identified by the typing of the semen that may be discovered on the body of the victim.

Fingerprints are well-known as the 'signature' left behind by the killer on weapons or articles of use. But no less incriminating are locks of hair, or articles of clothing left behind by him at the scene of the crime, or on the person of the deceased. In two interesting cases, the killer was identified by such evidence.

A young playwriter and director was assaulted by his own friend who also happened to be the hero of one of his plays. It was a case of the eternal triangle. Both were emotionally attached to the heroine of the play. The playwriter was assaulted with a jemmy; in the struggle that ensued, the hair of the assailant was gripped by the victim and a few locks came off.



Deformed foot of the assailant was a perfect fit to the footprints left behind by him at the scene of crime



Cuts on the hands of the assailant, received during the struggle, gave him away. They were caused by knife with defective handle

The hair remained in the hands of the deceased and became crucial in the identification of the assailant. In a second case a young lady scientist of BARC was murdered by her male servant, who assaulted her with a silver trophy cup. The blood-stained footprints of the assailant, found at the scene, suggested a deformity of the right foot; they matched perfectly the right foot which had the great toe curving inwards.

In yet another case, the assailant, while inflicting blows on the deceased with a knife, received multiple superficial cuts on his palms from the defective handle of the knife. He had sought medical help immediately after the crime. A similar thing happened in the Chopra murder case involving Billa and Ranga, where Billa was injured and sought medical help at Willingdon Hospital in Delhi.

In the famous Abhyankar multiple murders in Pune, a piece of clothing was left behind by the assailants in an unsuccessful attempt on one of the families. This proved to be a very vital link in connecting the accused to the crime. In the Gautam murder case (Lucknow), in which a headless body was found in a railway compartment, the assailant was found to be using personal effects of the deceased, like wristwatch, clothing, briefcase; by means of these he could be connected to the crime. These are some of the ways by which the killer is identified.

Dr. Phatnani heads the medical education division of a well-known pharmaceuticals firm and is guest lecturer in forensic medicine at the Seth G.S. Medical College, Bombay.

(continued from p. 65)

connected to the loudspeaker terminals, the sensitivity potentiometer has to be adjusted for proper light effect. The setting will vary according to the volume at which the music is played. When the potentiometer setting is at the maximum, most of the time the lamps may remain lighted. On the other hand, when the potentiometer is in the minimum position the lamps will not light at all. The optimum position can be determined by trial and error.

The power transistor 2N3055 requires a heat sink to dissipate the heat generated in controlling the brightness of lamps. Hence, the transistor has to be mounted on a commercially available heat sink or a aluminium sheet of size about 150 mm x 100 mm (3 mm thick). As the power transistor 2N3055 is mounted on the aluminium sheet or heat sink and as the collector connection of the transistor is its body itself, the aluminium sheet or heat sink has to be electrically isolated from the rest of the circuit.

All the lamps are connected in parallel; each should be 24 volts type. The total number of lamps should be such that the net load offered by them does not exceed 50 watts, that is, one can use up to 50 numbers of 24 volts 1 watt lamps or 25 numbers of 24 volts 2 watt lamps.

You will need :

Semiconductors : Transistor BC107 - 2 Nos.; BC177 - 1 No.; 2N3055 - 1 No.; Diodes BY125 - 5 Nos.; Zener diode 12V, 1W - 1 No.

Capacitors (all electrolytic) : 2000 mfd, 25V - 1 No.; 250 mfd, 25V - 1 No.; 10 mfd, 25V - 1 No.

Resistors : 470 ohms - 1 W - 1 No.; *Half-watt resistors:* 68K-1 No.; 56K-1 No.; 33K - 1 No.; 10K - 1 No.; 3.3K - 2 Nos.; 2.2.K - 1 No.; 1 K - 2 Nos.; 470 Ohms - 1 No.; 330 Ohms - 1 No.

Potentiometer : 1K carbon linear or wire wound - 1 No.

Transformer : (Made to order) : Primary 230V AC, Sec. 22.5V AC 2 amps - 1 No.

Approximate cost of the above components in Bombay market, Rs. 160.

Misc : 24V lamps with lamp holder (see text), aluminium sheet of size 150 mm x 100 mm and 3 mm thick, or heat-sink for transistor 2N3055, knob, ON/OFF switch, mains supply plug, suitable enclosure, wires, solder, screws, vero board or group board, 1 amp fuse with holder.

ANIL V. BORKAR

Brain Teasers

MANGO TIME : Ashok, Dilip, Jayant and Tushar were plucking mangoes in a grove to earn some pocket money during the summer holidays. Their earnings were directly related to the number of mangoes plucked and had the following relationship :

Jayant got less money than Tushar. Jayant and Tushar together got the same amount as Ashok and Dilip taken together. Ashok and Tushar together got less than Dilip and Jayant taken together.

Who got the most? Who plucked the least mangoes?

G. V. JOSHI *(Solution next month)*

Solution to last month's Brain Teaser [illegible]

The [illegible] could not have got the [illegible] Kindness, forgiveness, love and truth; so he got the non-violence award. The saint with love, getting the award for truth could not be Love, Truth, Forgiveness or Kindness; so he was Non-violence. Truth could not get the awards for truth, non-violence, love and forgiveness; so he got the kindness award, and Kindness got the love award. The truthful saint getting the forgiveness award was Love. Forgiveness was not the quality of Love and neither was it of Kindness, since the forgiver got his award after Kindness got his. Hence, Truth was the forgiver. This leaves Kindness, with the love award, also with the quality of non-violence. The whole set up is as follows (using the first letters only).

Name	K	T	L	N	F
Quality		f	t	l	k
Award for	l	k	f	t	n

No. 3
of a series giving the facts about India's new strike aircraft

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Jaguar International is an aircraft specialised to meet India's defence problems.

It is supersonic.

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It has twin-engine reliability.

It has formidable air-combat capability.

It can accept long periods away from base maintenance facilities.

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The whole concept of Jaguar as a tactical strike aircraft was based on the need for tactical air commanders to be able to react swiftly, flexibly and decisively to sudden changes in the battlefield situation. Jaguar's ability to operate at full load from improvised bases enables it to respond swiftly and decisively to calls for strikes on specific targets, either in or well beyond the immediate battle zone.

Rough-field capabilities.
With its rugged, trailing-link undercarriage, Jaguar is a superb rough-field aircraft. In trials, it has convincingly demonstrated its ability to operate without difficulty, in wet or dry weather, from short, unprepared grass strips or sections of motorway, with weapon loads of up to 10,500 lb, as cleared for normal runways. With minimal support facilities, it can be turned round between missions in as little as eight minutes and can sustain high mission frequencies in combat conditions.

Shortfield performance.
Exceptional shortfield performance stems from the well-balanced combination of high thrust/weight ratio, high-efficiency wing, and advanced landing-gear geometry, with low-pressure tyres. The wing, with a sweepback of 40 degrees at quarter chord, has retractable slats on the outboard leading edge and double-slotted trailing-edge flaps extending across the full span to the wingtips. As a result, typical circuit speeds are in the region of 130 knots and landing speeds around 115 knots. Typical landing and take-off run at normal load is only 1,600 ft. The slats can be used to augment manoeuvrability in combat.

Science Today, June 1980

Uneven surfaces.
The twin-wheel, trailing-link undercarriage and single steerable nose-wheel, fitted with very low-pressure tyres, enable Jaguar to operate safely from uneven surfaces with poor load-bearing characteristics.

High mission rates.
The aircraft has the reliability, ease of servicing and low maintenance needs essential for very high mission rates to be sustained from comparatively primitive airstrips. Single-point refuelling and replenishment of oil and LOX via four quick-release panels enable turn-round to be accomplished in eight minutes. Re-arming the cannon necessitates opening only a further three panels; all other weapon stores are carried on wing and fuselage pylons.

Strike radius.
Jaguar's internal fuel tankage gives it a strike radius of over 500 statute miles, depending on the mission profile flown. External tankage extends the possible radius of action to 875 statute miles. The self-contained navigation system makes the aircraft completely independent of ground-based aids.

Mission flexibility.
Within the total external load capacity of 10,500 lb, wide permutations of weapon mix are possible, giving Jaguar a mission flexibility which, combined with the speed of response made possible by basing the aircraft at forward airstrips, makes it the most potent tactical strike aircraft in production today.

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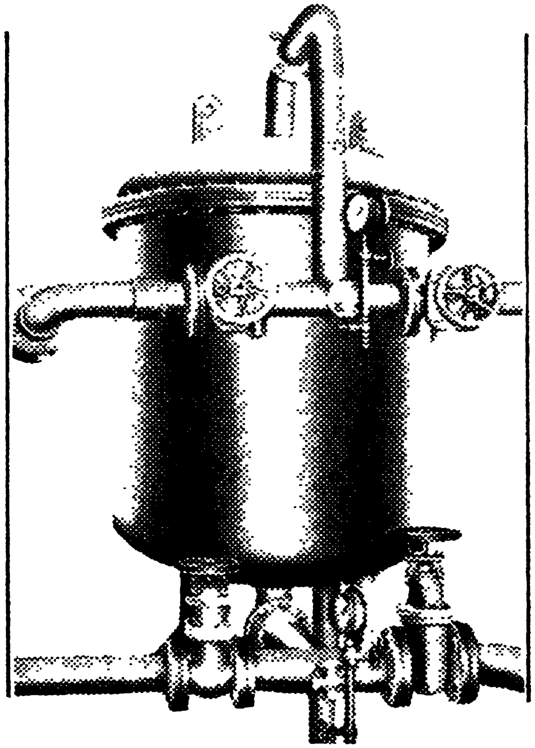
FROM INDIA'S MOST TRUSTED NAME IN WATER TREATMENT: A BREAKTHROUGH IN FILTRATION TECHNOLOGY. THE INDION UPFLOW FILTER*

What's an Upflow Filter?

The Indion Upflow Filter is another innovation in water treatment from Ion Exchange. It consists of a pressure vessel containing a synthetic filter medium lighter than water. When water passes through the vessel, the filter medium is compacted in the direction of the flow, trapping the suspended organic matter present in the water.

The filter is cleaned by reversing the flow of water through the vessel which releases the particles trapped during filtration.



What's special about the Upflow Filter?

The Upflow Filter scores over the conventational filter in three ways:

1) Only raw water is needed to clean the upflow filter. This saves the buyer the cost of a filtered water tank needed for cleaning a conventional filter,

2) The single layer filter medium cuts erection time and costs—whereas in a conventional filter the layers have to be placed one by one during installation.

3) Most important, the Upflow Filter can carry a specific flow rate which is four times greater than the conventional filter. Hence to filter a given flow, the filter size required is considerably smaller, resulting in major savings in transport, installation and space.

Take a look at the figures:

Unit Diameter (mm)	Flow rate (m^3/hr.)	
	Conventional Filter at 12m/hr.	Upflow Filter at 52.5m/hr
500	2.0	6.0
1000	9.0	25
1400	18	48
1600	24	63
2000	37.0	97

* Patent No. 143960

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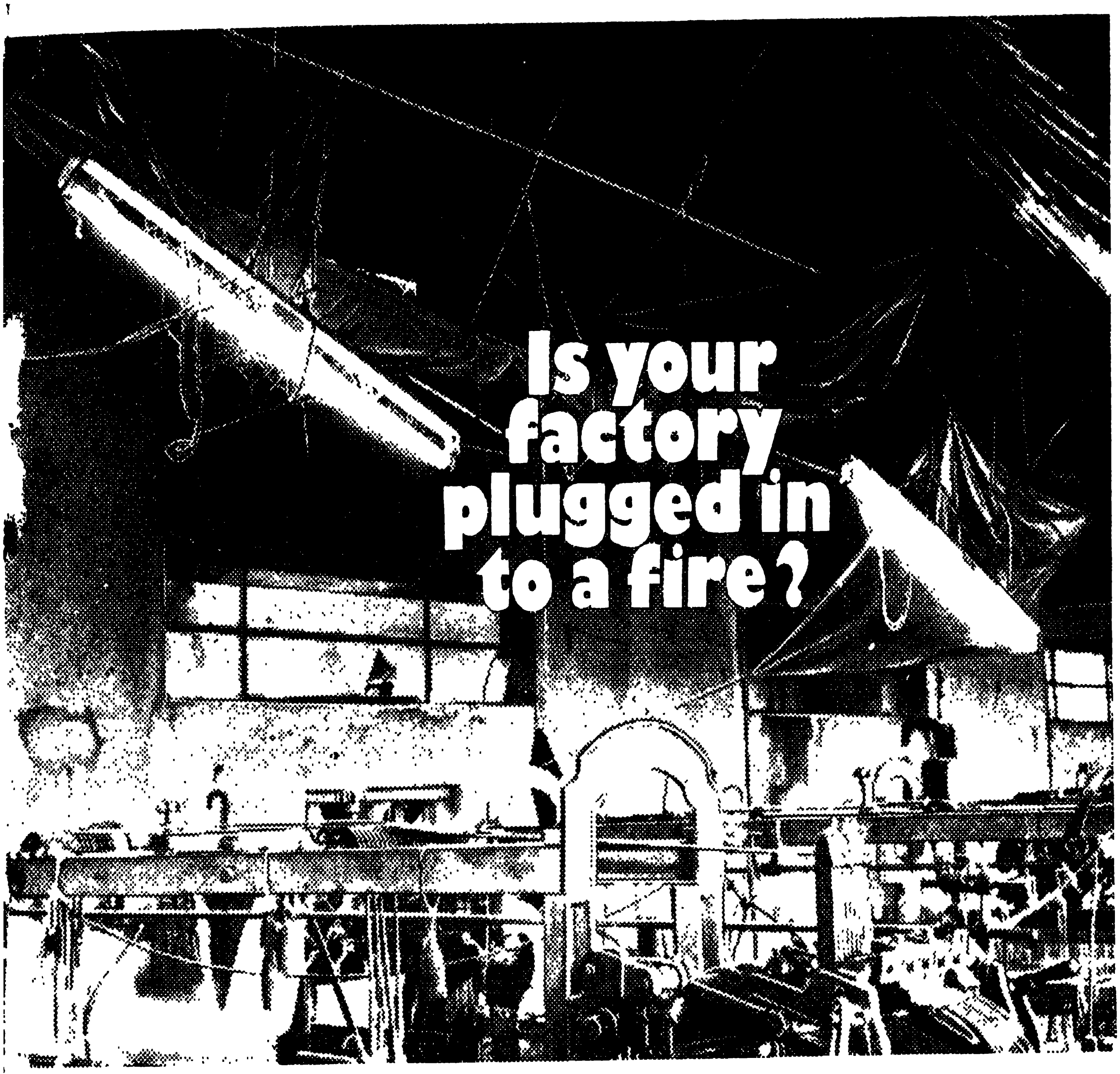

Most industrial fires are caused by faulty electrical wiring, connections and fittings. You cannot afford to neglect their silent threat to your establishment. Fire can ruin your factory, destroy your share of the market, your goodwill, irreplaceable equipment and raw material, the livelihoods of your employees. Fight fire before it fights you. Prevent it.

Your Fire Safety Checklist

Cut & keep

1. Arrange regular inspection and maintenance of all electrical fittings, connections and wiring.
2. Use only approved material from licenced contractors.
3. See that cables are adequately separated
4. Cable lines should be well protected at all stages.
5. Avoid temporary connections and extensions.
6. Investigate all fuse blowings immediately
7. Ensure suitable earthing of all electrical lines.

LPA welcomes your involvement. Please write for details.

Fire

Even a small fire can spread fast. Heat in one area brings surrounding areas to their 'flashpoint' and a fire can overwhelm you before you know it. Understand fire— and prevent it.

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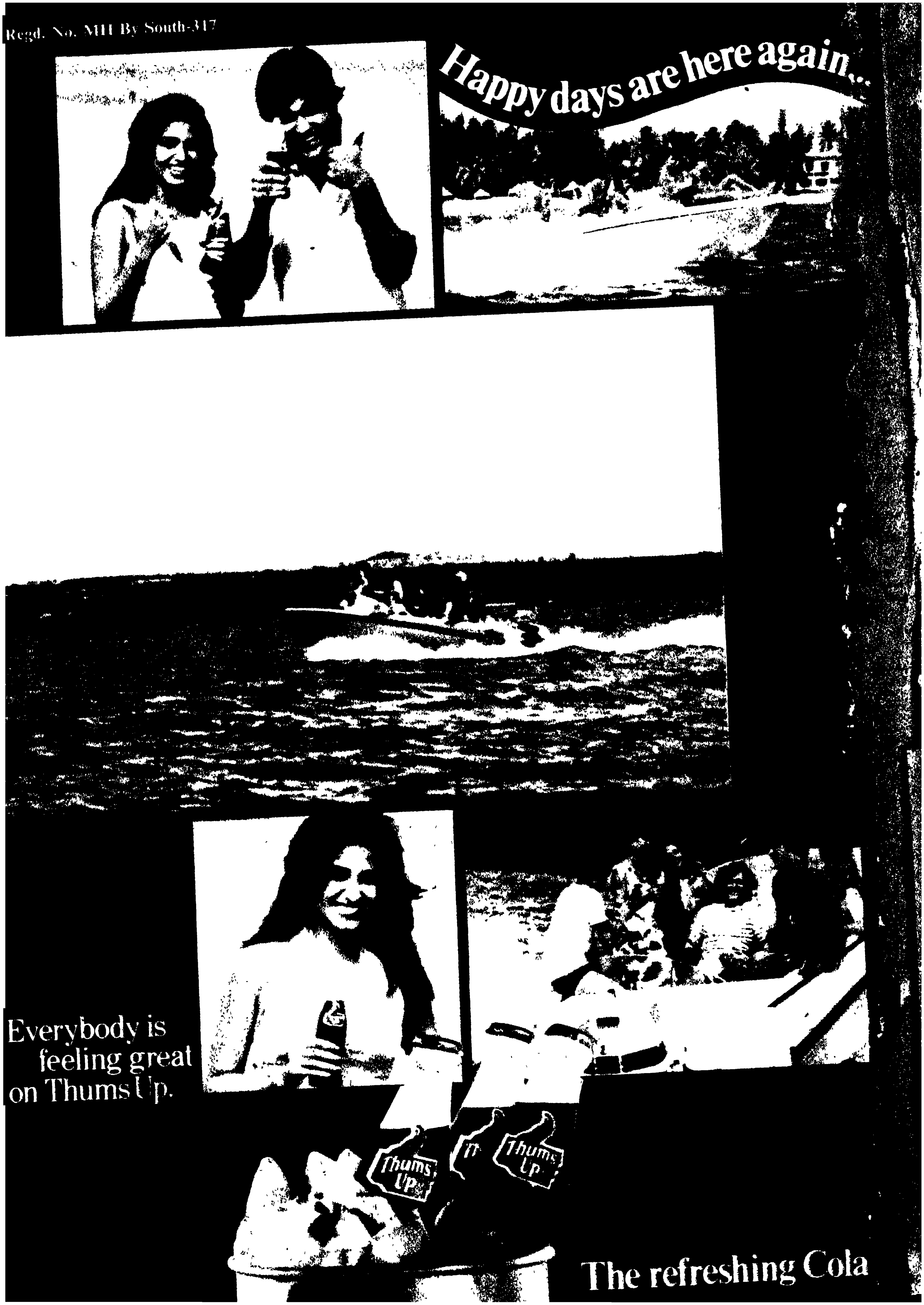
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